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Import Demand for ASEAN Hardwood Logs and Plywood in Selected Countries

by

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Luis P. Eleazar

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF Master of Science
IN
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Department of Rural Economy

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Spring, 1986

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Supervisor

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Date..20 December 1985..........

ABSTRACT

Foreign demand for ASEAN forest products is very important in the region's forest industry development owing to weak domestic demand. Access to foreign markets has become a prime preoccupation of many ASEAN timber producers and processors. However, knowledge about these markets and the determinants of foreign demand is scarce, which makes it difficult for ASEAN producers to gain access to these markets. With reliable quantitative information concerning demand factors, production and marketing problems facing the ASEAN forest industry may be solved effectively. Further, this can help to shape comprehensive policies on wood exports and production.

The purpose of the study is to analyze the import demand for ASEAN hardwood logs in Japan and South Korea, and hardwood plywood in the United States. In the course of the study, an examination of the geographical direction, distribution channels and trends of trade in hardwood logs and plywood was made. Also, an analysis of the three major markets, Japan, South Korea and the United States, was undertaken to determine the principal users of imports from ASEAN.

Import demand in Japan, South Korea and the United States was analyzed using four demand models: single equation static, partial adjustment and polynomial distributed-lag models, and the homothetic nonneutral translog cost function. These models were based on derived demand theory. Lack of data led to the use of translog model only in the study of the United States import demand. Using these models and quarterly time series data, the factors affecting import demand were examined statistically and the relevant demand elasticities and the time lag in import demand adjustment were estimated.

The study found that import price and the level of residential construction or production activity affect import demand in Japan, South Korea and the United States. Import demand is price inelastic in South Korea and more likely elastic in the United States. In Japan, domestic wholesale price of hardwood log imports has a stronger influence than import price in determining import demand. In all the three countries, import demand is directly related to the level of residential construction or production activity.

The results also showed that the principal users in the three importing countries have been efficient in adjusting their import demand in response to changes in import price, residential construction or production activity and prices of other inputs.

In the United States, the residential construction industry used imported hardwood plywood as substitute for domestic lumber and capital, and complement for domestic plywood and labor. Also, technical change in the industry has been hardwood plywood imports saving over time.

Other variables which showed significant impact on import demand are the principal users' expectations on future input prices and levels of housing construction or production activity as well as seasonal fluctuations.

Policy recommendations include: (1) Flexible charges on log exports which vary according to the stumpage value of logs in the world market, log grade and species class; (2) Creation of a market devalopment fund to assist producers to improve access to Japanese and the United States markets and to introduce lesser known species in South Korea; (3) Establishment of a timber marketing board to handle the marketing of hardwood logs and plywood; and (4) Lower export charges on plywood. Morever, market and product research and development programs are needed.

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I. INTRODUCTION

A. Background and Problem of the Study

The regional economy of the Association of South-East Asian Nations (ASEAN)[1] benefits greatly from the tropical forests and forestry sector at large, perhaps more than most citizens in the region recognize. For centuries the tropical forests served as a major source of the people's basic needs of food, water, materials and fuelwood. Added to these, the forest industry generates more income and employment in many rural communities as it continues to grow, and has contributed a billion dollars worth of foreign exchange earnings annually to the regional economy over the past three decades. Today forestry stands out as one of the region's leading industrial sectors in terms of export earnings and employment.

During the last three decades, the ASEAN dipterocarp species - commercially known as "lauan," "meranti," "seraya," or "Philippine mahogany" - comprised the bulk of hardwood logs and plywood imported by wood processing and other industrial firms in such developed countries as Japan and the United States and in some developing countries such as South Korea. The total value of these imports and other forest products sold in foreign markets have provided the

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[1] The ASEAN was founded in 1967 through the Bangkok Declaration, also known as the ASEAN Declaration. In this study the member countries referred to correspond to the five founding nations: Indonesia, Malaysia, the Philippines, Singapore and Thailand. Recently, the membership expanded with the participation of Brunei.

ASEAN governments an annual revenue of more than $4 billion for the last 10 years. Part of this amount has contributed much in the implementation of the governments' socio-economic development programs and the stability of the forest industry in the region. More importantly, the steady inflow of money in the areas in which the wood-based industries are located helped in the development and growth of the respective local communities.

Since the early fifties, world demand for tropical hardwoods, and logs in particular, has grown remarkably. Between 1967 and 1979 import demand for all hardwood logs[2] increased at an average annual rate of 5.37 percent (in roundwood equivalent volume), while log prices rose sharply during the period. Within this period much of the growth in world demand for tropical hardwoods was met by increasing harvest rates of fairly high-quality timber species. The capacity of the tropical forests to supply the growing demands in foreign markets was a significant factor for the regional economy. During most part of this period, however, the quantity supplied has responded primarily to the increasing demand for foreign exchange and additional capital, and to the weak effective demand in the domestic market. Thus, until the early 1970s, the forestry sector has flourished and the regional economy prospered as well. In recent years, hardwood logs and products have become a principal source of foreign exchange in Sabah (Malaysia),[3] rank second among major export commodities in Indonesia and rank fifth in the Philippines.

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[2] Refer to all woods derived from trees classified botanically as Angiospermae and include sawlogs, veneer logs and logs for sleepers. For the reference, see FAO, *Yearbook of Forest Products*, Food and Agriculture Organization of the United Nations, Rome, various issues.

But regretably for the respective governments, the large portion of tropical hardwoods that went to foreign markets until the mid-seventies were in the form of logs rather than processed products such as plywood. In fact, even later in 1980, hardwood log exports were about 30.5 million cubic meters, accounting for 80 percent of the world log trade. In contrast, exports of hardwood plywood were only 1.7 million cubic meters, or 42.5 percent of the world trade in this product.[4] As a result, potential gains from exports of processed products such as value-added and extra employment were virtually unrealized. In 1981, employment in the primary and secondary processing industries (sawmilling, plywood, veneer and blockboard) comprised some 250,000 employees, and may increase considerably if greater processing could be developed in the region.

The increasing world demand for tropical hardwoods, however, has created considerable pressure on the tropical forests in recent years in the form of rapid forest depletion and degradation of soil and water resources. At the same time, there has been an increasing general belief "that the flourishing log trade was the main cause of the stagnation of local processing and overseas marketing of manufactured timber."[5]

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[3] B.J. Sanvictores, *Subregional/Regional Co-operative Measures to Improving Marketing of Tropical Timber and Timber Products*, U.N. Economic and Social Commission for Asia and the Pacific, Bangkok, 1981, pp. 55-56.
[4] ASEAN/EEC, *Regional Study for the Commercialization of the Timber Resources in the ASEAN Countries*, Final Report, France: Centre Technique Forestier Tropical, 1983, p. 1

In August 1981, in order to tackle common problems within the region, the ASEAN Economic Ministers convened a meeting in Indonesia to formulate a common forestry policy. This policy is commonly known as the Jakarta Consensus on ASEAN Tropical Forestry. One of the main concerns of this policy focuses on "rationalization of forest industries development based on maximum possible value-added processing,... through the scaling down of log exportation and generating the production of more value-added products for exports."[6] This particular concern has led to a consensus among the ASEAN member countries to enforce a log export restriction policy in order to develop their secondary and tertiary wood processing industries and, at the same time, encourage export of more processed products.

Although this policy had already taken effect in some member countries at much earlier dates, it was essentially during the past four years that concerted and effective implementation has become evident. However, the policy has failed to consider the inherent nature of the forest industry in the region. That is, most wood-based industries (i.e., sawmill industry, plywood industry, etc.) in the region are largely dependent on the export market due to weak effective demand in the domestic market. This implies that the development of the forest industry in the ASEAN region depends upon the demand for forest products in foreign markets. Regardless of whether these products refer to unprocessed or processed products, the factors influencing foreign (or import) demand would be the major determinants of the type of products most profitable to produce. Thus, any policy designed to improve further the forest industry should be founded on a clear understanding of the factors affecting import demand for such products as logs and plywood. However, information on this aspect is lacking. Availability of this type of information would be considerably relevant, not only to policy makers concerned with the assessment and formulation of resource development and trade policies, but also, and more importantly, to the ASEAN producers concerned with the improvement of their production and marketing of the forest products.

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[5] J. Turbang, *Marketing of Tropical Timber Products and Co-operative Measures Among Producing/Exporting Countries of the South-East Asia*, UNCTAD/ECDC, March 1983, p. 12. This author acknowledges the permission of Mr. L. Waring of the FAO/UNDP Asia Pacific Forest Industries Development Group, Malaysia, to quote the paper of Mr. Turbang; as usual the opinions expressed are those of Mr. Turbang and not necessarily shared by UNCTAD and the UN Secretariats.

[6] ASEAN, "Jakarta Consensus on ASEAN Tropical Forestry," A document of the Third Meeting of the ASEAN Economic Ministers on Agriculture and Forestry, Jakarta, Indonesia, 12-14 August 1981, pp. 1-2.

This demand related issue is but one of the many issues surrounding the log export restriction policy that deserve serious investigation. It is therefore analyzed in this study, in order to formulate well-conceived measures that would enhance the economic position of the ASEAN forest industry. Other issues are related to the potential effects of the policy on income and employment, the capital investments necessary in the establishment of new wood processing plants, and the production efficiency of the industry to ensure competitiveness of the processed products in international markets. There are also some issues that relate to trade policies which may affect the exportation of processed products, such as tariffs and nontariff barriers and measures. Unfortunately, these other issues are beyond the scope of the present study. As already noted, this study focuses on demand for the ASEAN forest products in selected foreign markets.

Given the large number of countries comprising the traditional markets for the ASEAN forest products, this particular study selects those countries which are primary markets for either hardwood logs or plywood and most likely to be affected (positively or negatively) by the reduction in log exports from the region. These countries are Japan, South Korea and the United States. Japan and South Korea have been, and still are, the major importers of hardwood logs, with the former transforming logs into plywood and lumber primarily for domestic consumption and with the latter using logs to produce plywood for re-export to the United States.[7] On the other hand, the United States remains an important market for hardwood plywood. Knowledge of import demand for hardwood logs and plywood in these countries could provide some indication of potential gains associated with a policy shift away from log exports towards processed products. To determine import demand, the factors influencing it should be properly identified and examined in a systematic manner.

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[7] For a more detailed discussion, refer to chapter 2.

B. Study Objectives

The primary objectives of this study are fourfold. These are:

1. To determine and examine the factors affecting import demand for the ASEAN hardwood logs in Japan and South Korea, and hardwood plywood in the United States;
2. To estimate the relevant demand elasticities, adjustment patterns and time lag in import demand adjustment;
3. To ascertain the degree of substitution or complementarity between imports and domestically-produced wood products and primary factors in the production process; and
4. To document the pattern (i.e., origin and destination of traded forest products), distribution channels and general trends of trade in forest products with emphasis on hardwood logs and plywood.

A secondary objective of this study is to make a comparison of the empirical performance of the estimation models used in determining import demand for hardwood logs and plywood. It is hoped that the results of this study will help improve the general level of understanding of import demand determination and serve as a basis in the formulation of development and trade policies in the ASEAN region.

C. Scope and Methods

This study deals primarily with an analysis of quarterly import demand for the ASEAN hardwood logs in Japan and South Korea and hardwood plywood in the United States. Due to data limitations, the period covered by the study differs for each country (i.e., 1967-83 for the United States, 1970-78 for South Korea and 1979-83 for Japan). Quarterly data for all the variables used in the empirical analysis were obtained from published sources. Much of the data and information presented in chapters 1 through 4 were taken from secondary sources. In chapters 5 and 6 the data reported were basically results of the empirical analysis using the various demand models postulated for each country and the quarterly time series data collected.

Two procedures were employed in this study to fulfill the objectives set forth in the previous section. The first procedure was aimed at meeting the first three primary objectives. An examination of the developments in the use of hardwood logs in Japan and South Korea and of hardwood plywood in the United States has provided some information about potential factors influencing import demand and the principal users of these products. Further, a review of relevant theoretical concepts and analytical models was conducted to determine the appropriate theory and models that best fit the two intermediate products under consideration. This review has led to the application of derived demand theory, wherein the demand for the imported input (i.e., hardwood logs or plywood) is assumed to be derived from the demand for the product it produces. The resulting models have included single equation static, partial adjustment and polynomial distributed-lag demand models as well as a transcendental logarithmic, or translog, model. Due to data constraints, the latter model was utilized only in the study of import demand for hardwood plywood in the United States residential construction industry.

The second procedure consisted of a compilation and analysis of statistical reports and other publications to provide some insight into the evolving pattern (i.e., origin and destination of forest products), distribution system and trends of trade in forest products, giving emphasis on hardwood logs and plywood. Personal interviews with a number of forestry officials and experts from the government and private sectors in Malaysia, Thailand and the Philippines were undertaken to solicit their opinions on the general trends of trade in the near future that will likely occur and their probable impacts on the forest industry in the region.

The results gathered served as the bases for the conclusions, policy implications and recommendations made in this study.

D. Study Outline

This study is organized as follows. Chapter 2 provides an overview of the geographical pattern, distribution channels and general trends of trade in forest products, with emphasis given to hardwood logs and plywood. Also, it includes a discussion of trends in hardwood logs and plywood consumption and production by the major consuming and producing countries. This chapter ends with a review of developments in principal markets for the two intermediate products of interest.

Chapter 3 contains a review of relevant theoretical concepts and analytical models. It outlines the procedure in determining the appropriate characteristics of production technology in the residential construction industry and the derivation of factor demand functions using the translog cost function and Shephard's lemma. The importance of lags in import demand adjustment is also discussed, including sources and models used frequently to capture such delayed response. In order to provide information concerning the performance of some of the demand models and the relationship of hardwood logs and plywood to other factor inputs, this chapter reviews some of the most recent empirical works in this area.

Chapter 4 contains the theoretical framework and the final forms of the import demand models used in econometric analysis. The procedures in selecting the appropriate models and the techniques employed in estimating the models are also discussed. The latter part of the chapter concentrates on a discussion of the sources of data, and the procedures for the transformation of raw data and reconstruction of index data utilized in the empirical analysis.

Chapter 5 contains the results of empirical estimation of the several import demand models and some comparisons of the performances of each.

Chapter 6 provides a summary and conclusions, with some policy implications and recommendations for future research that arise from the present study.

II. INTERNATIONAL TRADE IN FOREST PRODUCTS

A. Introduction

In attempting to determine the factors affecting import demand for the ASEAN hardwood logs and plywood (or even forest products in general) in foreign markets, it is necessary to identify these markets first and examine whether their imports follow any obvious pattern (i.e., the level of residential construction). Only after these markets are identified, and major markets selected, can further investigation be conducted to determine the sectors within major markets which utilize imported hardwood logs and/or plywood. Answers to the following questions will assist in identifying the sectors and the likely factors that influence demand decisions for the imported products: Who purchases the products? What particular needs do the product satisfy? Where are they bought and in what quantity? Do the imported products have distinct attractive features which give them competitive edge over many other products? Analysis of trade statistics and some characteristics of trade in forest products can provide some insights into these issues. Examination of the geographical pattern of trade in tropical hardwood will reveal which countries are major markets for the ASEAN hardwood logs and plywood. In addition potential markets and competitors can also be identified. An analysis of the trends in international trade in forest products, specifically in hardwood logs and plywood, can indicate the magnitude of imports by major markets which is essential in finding out the size and quality of these markets. Such an analysis can likewise uncover some variables which tend to affect import demand.

Another area which should be considered in analyzing international markets is the system of forest products distribution. The importance of this aspect is seldom recognized in determining foreign demand for forest products as distribution is often viewed as nothing but an element of marketing. Yet in reality many producers and exporters obtain information regarding changing demand among end users, currency and trade regulations in importing countries, and specific needs and wants of end users through distribution channels. When the system of distribution is well developed, the flow of information could be expected to be rapid. There is reason to believe therefore that careful analysis of the structure of distributive trade in forest products can indicate not only the quality of the market but more importantly provide relevant information that would strengthen possible conclusions to be drawn on demand for hardwood logs and plywood when the results of the empirical analysis of this study are presented in later chapters.

This chapter has two basic purposes. First, the chapter will examine the geographical pattern, distribution channels and trends of international trade in forest products, with emphasis on hardwood logs and plywood. Trends in hardwood logs and plywood consumption and production by major consuming and producing countries will also be considered. Second, it will attempt to review the developments in principal markets for hardwood logs and plywood. These markets are Japan, South Korea and the United States. This discussion will be utilized to determine the major utilizing sectors and their activities, the likely trends in demand for the imported products and the current and future domestic supply in these countries. The next section highlights the prevailing geographical pattern of trade in tropical hardwoods.

B. The Geographical Pattern of Trade

The humid part of the intertropical world area which extends from the Tropic of Capricorn to Tropic of Cancer serves as the principal source of tropical hardwood that is traded in the international market. Countries within this tropical zone are grouped into three major producing regions: Africa, Latin America and South-East Asia. Apparently the pattern of trade in tropical hardwood originates from these regions and it is aimed towards Japan, North America and Western Europe.[4] Of these markets, Japanese market plays a major role in the evolution of world trade in hardwood logs, while North America (the United States in particular) and Western Europe remain important markets for hardwood plywood and other processed products.

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[4] K. Takeuchi, "Market Prospects for Tropical Hardwood from Southeast Asia," in J.S. Bethel (ed.), *World Trade in Forest Products*, (Seattle: University of Washington Press, 1983), pp. 432-446.

Between 1960 and 1982 the major pattern of tropical hardwood log trade can be schematically presented as in Figure 2.1. During the period, the flow of hardwood logs from the region of origin to their destination can be ranked in order of importance:

1. South-East Asia - Japan,
2. South-East Asia - Other Asian Countries,
3. Central and West Africa - Western Europe, and
4. Latin America - Western Europe.

South-East Asia - Japan trade flow has represented 30 to 40 percent of international trade in hardwood logs throughout the period under consideration. The magnitude of trade between the two areas has also increased over the years. South-East Asian exports of hardwood logs to Japan rose by 46 percent between 1960 and 1982, or from 3.2 to 13.8 million cubic meters. Japan's imports, on the other hand, have increased by a factor of fourteen for the period 1955 to 1973.[1] The next important trade flow which links South-East Asian producers to other Asian countries such as South Korea, Taiwan and Hong Kong started to become significant by the mid-sixties when industrial production in the latter countries expanded at a remarkable rate. Also their increased exports of plywood have accounted for their huge log imports from South-East Asian countries (Indonesia, Malaysia and the Philippines). These other Asian countries

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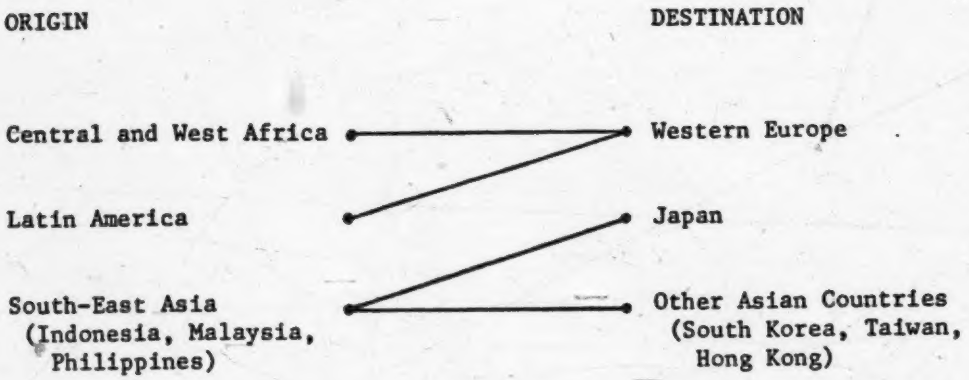
[1] J.G. Laarman, "Timber Exports from Southeast Asia: Away From Logs Towards Processed Wood," *Columbia Journal of World Business*, XIX (1984): 77-82.

Figure 2.1 Geographical Direction of Trade in Tropical Hardwood Logs


ORIGIN
DESTINATION
Central and West Africa
Latin America
South-East Asia (Indonesia, Malaysia, Philippines)
Western Europe
Japan
Other Asian Countries (South Korea, Taiwan, Hong Kong)

are commonly called "in-transit processing countries" since they import primarily hardwood logs to be processed into plywood for subsequent "re-exportation" to the United States, Europe and other countries.

Movement of hardwood logs from South-East Asia to other importing countries outside Asia has been very small and is now negligible.

The flow of log exports from Central and West Africa to Western Europe has been growing steadily over time especially after 1970 when supply from Latin America declined drastically. The decline in Latin America's exports was a result of log export prohibition in 1970 in Brazil, which essentially dominated the region's export flow. Thus, in 1980-81, not a single country from Latin America has been included in the ten major hardwood log exporting countries. At present, only Central and West Africa and South-East Asia are the main suppliers of hardwood logs in foreign markets. The important exporting countries from the former supply region include Gabon, Ivory Coast, Liberia and the Cameroons. In 1982 these countries have combined exports of about 3 million cubic meters to Western Europe (France, Italy, Spain, and the R.F.A.).[10]

Trade in hardwood logs is concentrated in a few countries because the product is bulkier than, say, plywood. Consequently, hardwood logs use ship space poorly. Thus the opportunity cost that is incurred by a liner will tend to raise its freight rates. This will tend to contrain distribution because the per unit value of logs is less than that of a finished product.

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[10] French Ministry of Agriculture, Forestry Division, *World Tropical Timber Trade*, Published by Association Francaise des Eaux et Forets, June 1985.

Although transport cost is considered the prime factor determining the pattern of trade in hardwood logs, the influence of major producing countries' export policies cannot be underestimated. The expansion of log exports from Central and West Africa to Western Europe was a typical example of a change in trade-flows due largely to log export ban policy pursued by Brazil. The current transition in South-East Asia (Malaysia, Indonesia and the Philippines in particular) to accelerate domestic processing of value-added products also indicates a possible shifting of geographical pattern of trade in hardwood logs. In fact, Asian in-transit processing countries, including Japan, have started looking for new potential sources of logs to make compensation for reduced logs from South-East Asia. It is likely that the ASEAN policy to restrict exports of hardwood in unprocessed form will lead to increased flow of log exports from Central and West Africa towards Asia. This is actually becoming evident today. If demand for hardwood logs in in-transit processing countries is price inelastic, producers in South-East Asia are more likely to benefit from supply restrictions to drive up the price of the product. The transport cost factor and heterogeneity of African hardwood species provide strong probabilities of varying South-East

Asian log prices. However, an outright prohibition of log exports is inappropriate under inelastic demand conditions, unless current log markets are willing to import processed wood products. This issue requires further investigation if the policy of 'no-log-export' is to be pursued. It is also important to ascertain whether or not the benefits foregone from curtailing log exports can be compensated by the benefits derived from a 'no-log-export' policy.

Trade pattern in hardwood plywood is diversified and involves a relatively larger number of participants than that of hardwood logs. Major trade pattern in tropical hardwood plywood is shown in Figure 2.2. Although Central and West Africa, Latin America and East and South-East Asia all export hardwood plywood, it is the last group that accounts for the largest proportion of world exports. Takeuchi[11] identifies two types of Asian exporters: those comprising the "log-producing countries" such as Indonesia, Malaysia, and the Philippines, and the "log-importing countries" such as Japan, South Korea, Taiwan(China) and Hong Kong.[12] The second type of Asian exporters was the largest supplier of hardwood plywood to the United States and other countries until 1980. From the destruction of the Second World War, Japan reconstructed its economy through the development of some basic industries that have export potentials, one of which was the wood processing industry. Consequently, Japan served as the main supplier of tropical

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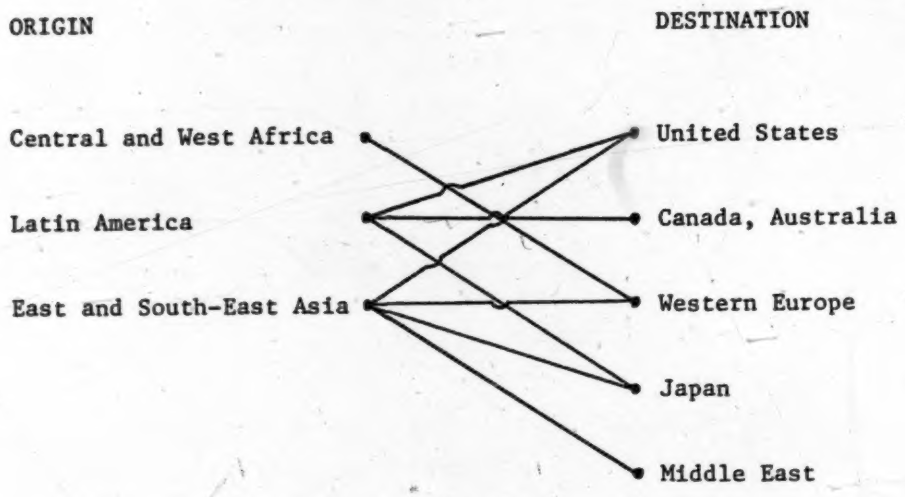
[11] K. Takeuchi (1983), p.434.
[12] K. Takeuchi, op. cit., p. 434.

Figure 2.2 Geographical Direction of Trade in Tropical Hardwood Plywood


ORIGIN
DESTINATION
Central and West Africa
Latin America
East and South-East Asia
United States
Canada, Australia
Western Europe
Japan
Middle East

hardwood plywood in the world market, which lasted until the mid-1960s. However, the tremendous increases in domestic consumption since then due to unprecedented economic growth and strong demand for housing did not allow the processing industry to make exportable surplus. In addition, Japan began a transition from a supplier of labor-intensive products to that of capital-intensive commodities. After this period, Japan's position of being the major exporter of hardwood plywood was taken up by South Korea and Taiwan. These two countries accounted for 20 to 30 percent of world exports between 1970 and 1981. Prior to 1979, significant plywood exports from log-producing countries in Asia originated mainly from Malaysia and the Philippines but they were substantially smaller compared with the exports of in-transit processing countries.

In 1980 Indonesia, which is considered the richest forest resource owner in the Asia-Pacific region, banned the exports of logs in order to encourage greater domestic processing and exports of more value-added products, especially plywood. Subsequent establishment of several plywood mills and rapid plywood production have enabled Indonesia to surpass the traditional exporters in less than three years. This rapid expansion coincided with depressed worldwide economic conditions and construction activity in major market areas, the United States in particular. As a result, a temporary oversupply of hardwood plywood in foreign markets has occurred. This indicates the sensitivity of foreign demand for imported products to variations in economic and political conditions in main market areas. It is likely that international demand for hardwood plywood will be increasingly influenced by a changing economic and political environment in which trade takes place.

Today the ASEAN producers seem to have surpassed in-transit processors in supplying world markets.

The main importer of Asian hardwood plywood is the United States, followed by Middle East countries (Saudi Arabia, Egypt, Kuwait and Libya) and Western European countries (Italy, France, Belgium, West Germany, Luxemburg, and United Kingdom, to mention a few). In 1982 about 20 percent of East and South-East Asian plywood exports (in quantity terms) went to the United States, 15 percent to Middle East countries and 11 percent to Western European countries.

The foregoing discussion reveals that markets for the ASEAN hardwood logs - especially those coming from Indonesia, Malaysia and the Philippines - have been confined mainly to Asia. Most of these markets (notably South Korea, Taiwan and Hong Kong) are indeed large secondary processors who in turn re-export processed products overseas. The result is that these processors become strong competitors of plywood producers in the ASEAN region in supplying foreign markets. There seems to be strong possibilities for market expansion in the case of hardwood plywood provided more attention is placed on understanding the basic needs and wants of end users in the importing countries, and the factors that govern foreign demand for the product. In the next section, the distribution channels in forest products trade are examined in a more general manner.

C. The Distribution Channels in Forest Products Trade

Dramatic changes are currently taking place in the distribution system of forest products, in both domestic and overseas markets. Rich [13] and Turbang [14] characterize these changes as "channel bypassing" and "forward integration." Both are designed toward increasing the efficiency of the forest products distribution. Traditionally the transfer of forest products from the producer to the end user, who may well be in another part of the world, has worked through the following channels: producer - exporter - agent - importer - merchant and/or industrial consumer - end user, as shown in Figure 2.3. Each member in this system performs a role or some functions in order to effect efficient flow of goods from the main source of supply to the final point of consumption. This section will discuss each member's functions and then examine the changes that have occured.

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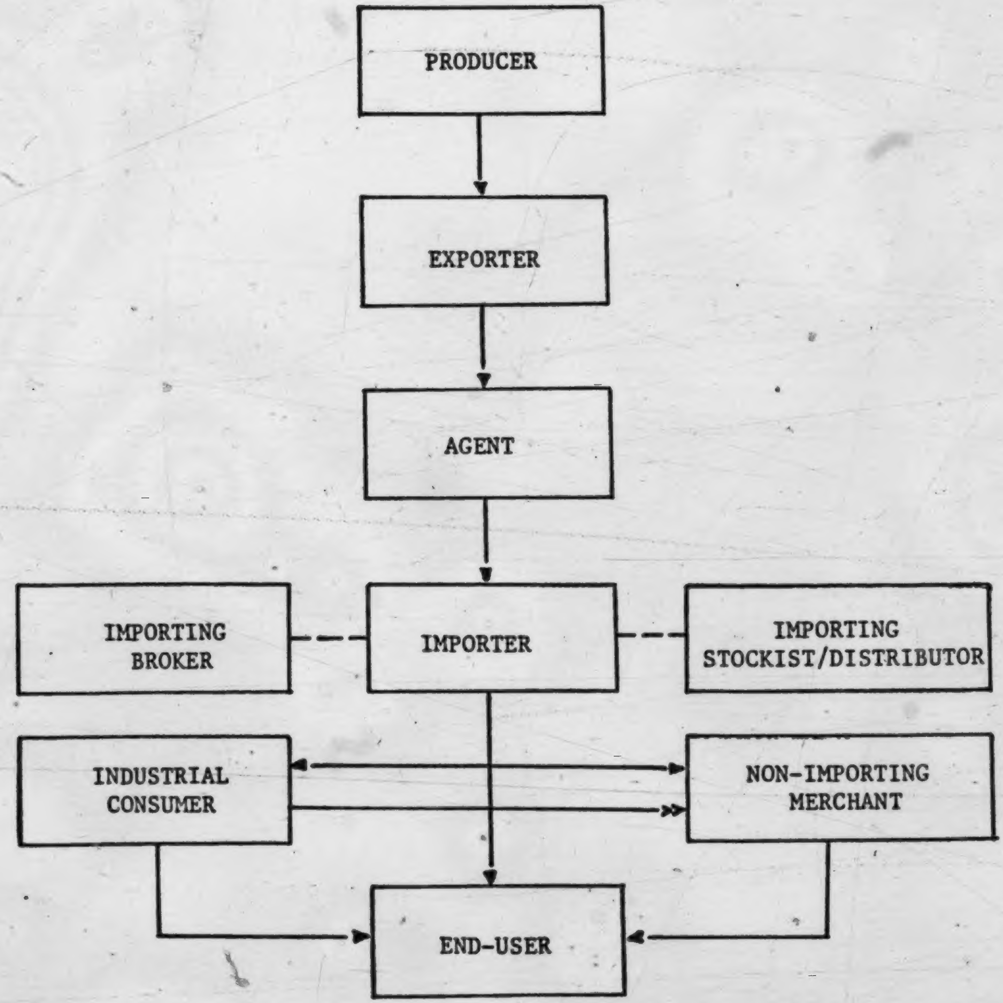
[13] S.U. Rich, *Marketing of Forest Products: Texts and Cases* (New York: McGraw-Hill Book Company, 1970), Chapter 6; and "Distribution Channels in the Wood Products Export Market," *Forest Products Journal*, 31(1981): 9-10.
[14] J. Turbang, op. cit., pp. 43-49.

Figure 2.3. Trade Channels in Tropical Hardwoods


PRODUCER
EXPORTER
AGENT
IMPORTING BROKER
IMPORTER
IMPORTING STOCKIST/DISTRIBUTOR
INDUSTRIAL CONSUMER
NON-IMPORTING MERCHANT
END-USER

Traditional Channels of Distribution

Figure 2.3 depicts the traditional trade channels in forest products. The role played by the producer in this system is mainly a provider of products required by the end user. He is either a forest owner or licensee and operates a mill to process the harvested logs into proper measurements and particular products based on the requirements of the end user in the importing countries. Information relating to product specification (dimension, design, etc.) and grading rules are conveyed to the producer by the exporter to ensure acceptability and competitiveness of the product in foreign markets. The exporter (shipper) buys wood products from the producer and sells to overseas importers with or without going through an agent. This type of exporter is known as "export wholesaler" because his main work involves buying and selling without participation in the ownership of a processing mill. Some export wholesalers also act as purchasing agents for importers but collect their commission from the producer.[15] Where the exporter is himself a producer or owner of a wood processing mill, he is called an "export producer."

In the hardwood trade, export wholesalers dominate export producers in terms of number. Producers have little influence over the price of the products, which is largely determined in the international market. Due to this, exporters bargain with the producers for the price of the product, while at the same time negotiating for a competitive price for the same product in the market place. With no means of obtaining information on the market price of the products and the needs and wants of consumers in the importing countries, producers are left in a disadvantaged position to the benefit of exporters and overseas consumers. Typically, the exporter employs the services of an accredited agent in the country to which he sells his products and passes on to the latter all the details about the products.'' For an exporter, the agent is a source of information and is responsible for protecting him against any loss arising from the inability of the buyer to meet his financial obligation.

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[15] Ibid, p. 43.

The agent serves as the link between the two large contracting traders - exporters and importers. Rich summarizes the agent's functions in the following words: "the agent, places orders with the exporters (shippers), arranges for shipments from the exporter and follows up to to be sure deliveries are made and payments received."'' Apart from these duties, the agent is expected by his principal (the exporter) to promote and find buyers for the principal's products in the country within which he operates, and to be alert to changing demand among consumers thereby providing his principal an up-to-date report. Not

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''J.H. Leigh, *The Timber Trade - An Introduction to Commercial Aspects* (Oxford: Pergamon Press, 1971). The 'details' may refer to the dimension, species and quality of the products under consideration using the various acceptable grading systems.
'' S. U. Rich op. cit., p. 9.

only should he be perceptive about market demand changes but he must also be conversant with currency and related trade regulations. As a matter of fact, all documents necessary in the transaction are the agent's responsibility, from delivery instructions, insurance and payment receipts to problems related to claims and complaints. In many instances, the agent also extends credit to both the exporter and the importer. His ultimate job is to carry the contract to the satisfaction of the parties involved. The agent, however,is not a permanent employee who could easily be replaced by his principal if he fails his job, and receives payment for his services only if a sale occurs.

Leigh points out that an agent can also be a broker, who can "find the market for an importer who wishes to dispose of landed stocks or of goods en route to him which his market, for one reason or another, cannot absorb at the time."[18] In this regard, the broker has to look for other importers or merchants to whom he can sell the undisposed stocks in order to avoid accumulation and slow turnover on sales. This type of agent (i.e., acting as broker at the same time) is common in both hardwood and softwood trades.

The importer typically purchases forest products from the exporter through an agent. Both the quantity and type of products to be ordered depend on the importer's assessment of the likely demand in the market in which he operates. After the products have been received, the importer resells them either to the industrial consumers (i.e., secondary converters of primary wood products), merchants (i.e., wholesalers and retailers), or directly to the end users (homeowners and contractors).There are two types of importers. One type of importer transacts with the exporter and buys forest products without specific consumer demand in view but with the expectation of finding buyers prior to the arrival of the products. This importer is known as "importing broker," "brass-platter" importer or speculator since his import decisions rest primarily on his speculation about the likely requirements of his consumers and the movements of the market price. His buyers are not concentrated in the country in which he conducts business but extend overseas to other importers in order to assure a market for his ordered products. These other importers are important in case he fails to find domestic buyers because he usually does not own stockyards or wharves and only utilizes public storage when he needs to land products. This type of importer avoids, as much as possible, carrying inventory. He is a trader who prefers to deal in "documents" and not "goods". His counterpart, the second type of importer, is commonly called an "importing stockist/distributor" or "stocking wholesaler."[11] He deals with goods, not documents, and has the usual practice of storing his imports to serve his buyers' requirements punctually. This type of importer appears to be more dependable compared to an "importing broker" because he normally owns huge stockyards and frequently will have facilities for further conversion and drying of wood products which he has to maintain efficiently to make sure the relatively high fixed overheads are met. Unlike the "brass-platter," the importing distributor sells primarily to non-importing merchants, the end users and less likely to other importers.

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[18] J. H. Leigh op. cit., p. 15.

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[11] See J. Turbang, op. cit., p. 45; and S. U. Rich, op. cit., p. 10.

In terms of purchasing and selling methods associated with product specification, the importing broker is generally selective. He will purchase only those wood products which meet the required specifications of his consumers. In contrast, the importing distributor buys a broader range of products (not restricted to a limited range of grades, species, sizes, etc.) allowing buyers for a wider range of choice. Importers may also differ in their specifications depending on whether they are dealing with hardwoods or softwoods. As Leigh correctly observes:

> In hardwood where the range of species is very wide indeed and imports come from many different countries, importers and agents tend to specialize in certain types of timber or in those which come from certain areas of the world. Importers' individual purchases of hardwood, whether of logs ..., tend to be on a smaller scale than those of ... plywood, and are often confined to a particular

species.[29]

Indeed until recently, the hardwood species which are widely traded are still the traditional ones. For instance, the most favored hardwood species originating from Southeast Asia are those belonging to the family Dipterocarpaceae (the genera Parashorea, Shorea,and Dipterocarpus).

Industrial consumers and non-importing merchants differ slightly in their functions and requirements for the imported products. A large fraction of the purchases of industrial consumers are unprocessed products such as logs, which they use to produce a multitude of industrial products (claddings, joints, mouldings and millworks). These industrial products are subsequently re-exposed to non-importing merchants and end users. Thus the double-arrow line in Figure 2.3 indicates that the industrial users sell to non-importing merchants and not the other way around. The single arrow line reflects the traditional trade links. The non-importing merchants are primarily retailers who obtain their stock from importers for the final users' day-to-day requirements, although some of them are wholesalers. Most of their sales are for a variety of building materials such as cabinets, joints, mouldings, millworks and claddings. In some cases they perform the function of industrial consumers as they also manufacture some building materials and furnitures. Distinction of industrial users from non-importing merchants is important for the producer in the supplying countries. Turbang points out that the industrial consumers "... represent a major market for the primary wood manufacturers, and are most valuable customers because their business depends upon receiving a regular and reliable supply of materials suitable for their needs."[21] Non-importing merchants, on the other hand, represent an important market for semi-to-finished wood products. Knowledge of the size of industrial consumers and non-importing merchants in specific markets and the factors influencing their purchasing decisions can provide sufficient bases in assessing the demand for forest products in these markets.

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[29] J. H. Leigh, op. cit., p. 16.

The importance of end users which include homeowners and building and related contractors in the analysis of foreign demand for forest products cannot be ignored. Their particular needs dictate the quantity and type of products the importers purchase from the exporters and influence the industrial products made by industrial consumers. Building contractors are the main users of wood products whose purchases are largely dependent upon their customers' specifications, preferences and lifestyles. Trends in construction activity have important implication for forest products demand, as for other inputs. It is reflected both in the composition and volumes of the products purchased by the contractors.

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[21] J. Turbang, op. cit., p. 46.

Three sectors or channels in the distribution chain deserve attention in attempting to determine the factors that affect foreign demand for particular products. For logs, for instance, emphasis must be placed on industrial consumers. Non-importing merchants and end users should be the focus of analysis when the product in question refers to semi-processed or finished products (i.e., plywood). However, it is possible that the end users may exhibit stronger influence on demand for imported logs than industrial consumers especially if they are the major users of the products which logs helped to make. Early forest sector demand studies[22] have generally considered end users (notably the building construction industry) to be the most important sector utilizing wood products.

Recent Structural Change

The traditional structure of the distributive trade has changed in recent years. The most significant changes are characterized by channel bypassing and forward and backward integration which have the effect of reducing the number of middlemen. These changes are not mutually exclusive and each seeks to speed up the flow of goods to coordinate production and sales better, and to improve the information flow between producers and end users.[23] The effects of channel bypassing and integration have also meant some efficiency saving (i.e., same functions/output can be achieved at less cost) as a result of fewer but large units in the distribution chain,[24] and closer cooperation between different large trading groups on an international basis. The changes in the current distribution pattern apply to the exporters and producers as much as to the importers and end users.

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[22] Some of these studies are reviewed in chapter 3.

[23] S.U. Rich, op. cit., p. 194.

Exporters can make a direct deal with large importers without employing the services of an agent so as to eliminate the costs on commission.[25] Another alternative is to set up sales offices in the countries to which they export to undertake the selling and promotional tasks overseas effectively, in order not to be out of the market as a result of increased competition from non-wood building materials (i.e., structural clay products, cement products, and so on).

Apart from entering a contract directly with exporters (rather than going through an agent), importers could bypass merchants and handle domestic sales to several end users due to improved road networks and communication facilities. Similarly, building contractors can aim to reduce costs through bypassing merchant-retailers and purchasing their materials directly from the wholesalers or even from importers involved in manufacturing. The costs usually include the services rendered (i.e., break-bulk shipments, warehousing, delivery, etc.) by the merchant dealers, which at the latter stage are no longer needed by the builders due to increasing availability of excellent communication facilities which enables them to contact and arrange orders with appropriate wholesalers or importers.

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[24] This author is grateful to Prof. Linda Chase Wilde for raising this point.
[25] S.U. Rich, op. cit., p. 9.

Integration in distribution into fewer but larger units is increasingly practiced in many industrialized countries such as Japan, the United States, Canada and the United Kingdom among others. In effect the number of importing firms has shrunk. Some importing firms have also set up their own wholesale distribution system to maximize the gains by way of reduced costs of distribution per unit volume of the product arising from economies of scale.

D. Trends in World Wood Economy

This section will examine worldwide trends in consumption, production and trade of all forest products, including the principal countries involved. Particular emphasis will be given to tropical hardwood logs and plywood. However, since available data do not provide separate statistics for hardwood and softwood plywood, this commodity includes both coniferous and non-coniferous components.[24] A notable feature of the growth in forest products trade concerns the disparities in growth rates among major commodities, and among major regions and countries.

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[24] It should be made clear that in Chapter V when the results of the econometric analysis are discussed, the imported plywood refers to hardwood plywood only.

World Consumption of Forest Products

Table 2.1 shows the apparent consumption of roundwood and selected wood products by geographical region, on both total volume and per capita bases, for 1980. It can be inferred readily from the table that the consumption of roundwood and wood products, particularly of sawn wood and sleepers, and of wood-based panels, is not evenly distributed across regions. The affluent regions, such as North America, Europe, USSR and Japan, have in general higher per capita consumption than the developing regions, except for fuelwood. This is attributed to their economic growth (i.e, real GNP) which provides for increased consumption or expenditures in the household sector, and investment in the industrial sector (i.e.,construction and manufacturing). Preston argues that this is a reflection of "positive correlation between affluence and industrial wood use."[27] This leads one to suspect that demand for forest products in most industrialized countries will rise with their real gross national product. The regions of Africa, Asia (excluding Japan) and Latin America, while accounting for nearly three-fourths of the world's population, have a combined per capita consumption of industrial roundwood of only 0.08 cubic meter. This per capita consumption was about one-fourth of the world average of 0.31 cubic meter and only one-twelfth of the developed regions (0.98 cubic meter).[28]

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[27] S.B. Preston, "Factors Affecting the Increased Worldwide Use of Wood," in J.S. Bethel (ed.) (1983), pp. 328-339.

[28] Ibid, p. 333.

Table 2.1. World Consumption of Selected Forest Products, 1980

REGION	Populations (Millions)	Roundwood				Products				
		Total Volume (m^3X10^3)	Per Capita Volume			Sawnwood and Sleepers		Wood-based Panels		
			Fuel Wood (m^3)	Industrial Wood						
				Total (m^3)	Hardwood Logs (m^3)	Total (m^3x10^3)	Per Capita (m^3)	Total (m^3x10^3)	Per Capita (m^3)	Plywood Per Capita (m^3)
WORLD	4 415	3 021 101	0.37	0.31	0.058	423 907	0.096	100 975	0.023	0.009
Developed	1 137	1 264 885	0.13	0.98	0.090	347 596	0.306	89 912	0.079	0.029
North America	246	463 261	0.08	1.81	0.172	106 565	0.433	33 125	0.135	0.065
Europe	484	351 868	0.09	0.64	0.088	99 721	0.206	35 939	0.074	0.011
Oceania	22.8	24 027	0.26	0.89	0.258	5 753	0.252	1 142	0.050	0.008
USSR	267	340 990	0.29	0.99	0.080	92 897	0.348	9 384	0.035	0.007
Japan	117	84 739	0.02	0.71	0.196	42 660	0.365	10 322	0.088	0.068
Developing	3 278	1 755 210	0.46	0.08	0.030	76 261	0.023	11 064	0.003	0.002
Africa	469	427 583	0.82	0.09	0.029	9 051	0.019	1 364	0.003	0.001
Asia (excluding Japan)	2 441	966 345	0.34	0.06	0.031	44 057	0.018	5 826	0.002	0.002
ASEAN	263	241 918	-	-	0.122	7 393	0.028	2 110	0.008	0.002
Latin America	368	361 282	0.78	0.20	0.079	23 153	0.063	3 874	0.011	0.004

Notes: Population data from U.N. Demographic Yearbook 1980; Volume data estimated from FAO Yearbook of Forest Products 1981; Preston, S.B., "Factors Influencing the Increased Worldwide Use of Wood" in World Trade in Forest Products (edited by J.S. Bethel) Seattle, University of Washington Press, 1983, p. 334. Columns may not add accurately due to rounding. Except for columns on per capita consumption of hardwood logs and plywood, and the row on ASEAN, the data were taken from Preston's article.

In the case of hardwood logs and plywood, the per capita consumption of the affluent regions in 1980 was, respectively, three- and fifteen-fold greater than the developing regions.

On a worldwide basis, per capita consumption of industrial roundwood, and sawnwood and sleepers has declined by 0.3 and 0.6 percent respectively between 1970 and 1980 (Table 2.2). This decline in per capita consumption has taken place in most affluent regions/countries such as North America, Oceania, USSR and Japan, with the sole exception of Europe. On the other hand, the less affluent and more populous regions of the world have displayed large annual increases in both total volume and per capita consumption of roundwood, and sawnwood and sleepers during the period.[29] A significant change in worldwide wood consumption has been recorded for wood-based panels which increased by 3 percent per year over the period under review, indicating an expanding market for plywood, blockboard, fiberboard and particleboard. These findings substantiate the prior discussion by allowing a comparison between the relative and absolute changes in the pattern of consumption of forest products. In terms of relative change in consumption, the developing countries have shown increasing trend while the affluent regions exhibited the opposite (except Europe). This is evident in the negative annual change in per capita consumption for the latter regions during the period under

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[29] Ibid, p. 336.

Table 2.2 Annual Change in Apparent Worldwide Wood Consumption, 1970-1980 (%)*

Region	Industrial Roundwood		Sawnwood and Sleepers		Wood-based Panels	
	Total	Per Capita	Total	Per Capita	Total	Per Capita
WORLD	0.9	- 0.3	0.3	- 0.6	3.6	3.0
North America	0.7	- 0.1	0.4	- 0.5	1.6	0.8
Europe	0.8	0.3	0.8	0.3	4.5	3.9
Oceania	-	- 0.4	- 0.8	- 2.5	3.1	1.5
USSR	- 0.7	- 1.6	- 1.9	- 2.8	5.6	4.6
Japan	- 1.0	- 0.2	- 0.7	- 0.2	2.3	1.2
Africa	2.9	-	4.6	1.7	6.6	4.1
Asia (excluding Japan)	4.4	1.8	3.4	1.2	9.7	6.9
Latin America	4.5	1.6	3.9	1.4	8.8	6.1

*Adapted from Preston, S. B., _op_. _cit_., p.335.

review. The affluent regions, in contrast, have larger consumption than the developing regions in absolute terms.

Two factors seem to explain the expansion in wood consumption in the developing regions, particularly in Asia. The first factor concerns the unprecedented growth in the economies of some middle-income countries, which fall under the category of developing countries, like South Korea, which now require larger quantities of forest products to supply the growing demand from several industrial sectors (i.e., construction and civil engineering) in their respective countries. The other factor involves the combined effect of enlarging population and modest economic growth. Mainland China is a good example. Lately, this country has been importing such wood products as sawnwood and plywood in appreciable amounts as she begins to improve her ports, bridges, cities and housing conditions. Population and national income represent two important economic variables which can affect demand for forest products through increased demand for housing. For example, a natural growth in population would render the actual housing stock insufficient to meet present requirements. As a result, there would be an increase in construction per capita and hence demand for forest products. The effect of income change will be reflected both in the structure and quantity of the product demanded.

Although the total industrial roundwood consumption has decreased slightly from 1970 to 1980, hardwood log consumption appeared to be increasing. The next subsection will discuss specifically the consumption trends of hardwood logs and plywood, and identify factors governing such trends.

Trends in Hardwood Log and Plywood Consumption

Takeuchi has found out that the:

> world consumption of tropical hardwood had grown rapidly over the period from 1950 to 1980, compared with consumption of softwood logs and temperate hardwood. Annual growth rates over the 1961 to 1980 period for tropical hardwood, temperate hardwood, and softwood were 4.8 percent, 0.7 percent, and 1.2 percent, respectively.[30]

He attributed these differential growth rates to the substitution of tropical hardwood for temperate softwood and hardwood which largely took place in the industrial temperate countries during this period. This substitution was actually motivated by the following factors: (1) the shortage of supply of temperate softwood and hardwood logs, (2) the rapid rise in the availability of hardwoods from tropical countries,[31] and (3) the relatively low price of imported tropical hardwood compared with those of domestically-produced hardwood and softwood logs on one hand, and the high costs involved in the production of the latter products on the other. The latter two factors characterize the forest industry in South-East Asia when it comes to their export of tropical hardwood logs, and the East and South-East Asia in terms of exportable hardwood plywood. Theoretically the demand for imported tropical hardwoods will vary inversely with their respective prices and directly with the prices of competing products available in international markets. The magnitude of the cross elasticities of demand for imports with respect to prices of competing products depends on the strength of substitution relationships that exist between them. Larger values of cross price elasticities in absolute terms reflect strong substitution (complementarity) relationship, while those values tending towards zero indicate a weakening substitution or complementarity.

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[30] K. Takeuchi, op. cit., p. 440.
[31] Ibid.

Tropical hardwoods generally are used by the construction and furniture industries and as such, the demand for these tend to depend on the world economic growth, and those of the industrial countries in particular. Interestingly enough, however, is the fact that consumption of tropical hardwood logs increased at 3.1 percent per annum compared to only 0.3 percent per annum for softwood logs.[32] This is particularly surprising in that the increase occurred during the 1970-80 period of depressed economic growth -when the world economy was hard hit by OPEC's collusive action to hold the supply and raise the price of oil in 1973-74 and 1979, and prices of most traded commodities rose sharply. It appears that the annual consumption rate of tropical hardwoods tends to move with, though slightly lower than, the economic growth of consuming developed countries. In addition the relatively low prices of tropical hardwoods seem to be an important force underlying their increased demand over the last three decades. During the years 1981-83, world consumption of hardwoods declined due to the depressed conditions in residential and other construction industries in such important countries as Japan and the United States.[33]

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[32] Ibid, p.441.

Examination of hardwood log consumption by individual countries, between 1964 and 1981, revealed that major consumers consist predominantly of developed countries, such as the US, USSR and Japan (Table 2.3). These three countries alone accounted for nearly one-third of the world total consumption of hardwood logs. Of the developing countries, China, Brazil and India showed significant increases in total consumption over the period. These data (Table 2.3) provide two interesting points : (1) that the ten largest consumers of hardwood logs accounted for 60 percent of the world total consumption, and (2) that the composition of the ten leading consuming countries did not change much for almost two decades.

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[33] In some consuming countries however, such as the United States, total wood consumption has started to rise in 1983 due to sharp increase in total new construction. In the United States, this turnaround resulted from a declining mortgage interest rates which made new homes more affordable. For this, see U.S. Department of Commerce, "Construction Outlook for 1984," *Construction Review*, 29(1983): 3-18.

Table 2.3. Largest Consumers of Hardwood (NC) Logs[1/] in 1964, 1971 and 1981*

Rank	1964			1971			1981		
	Country	Quantity $m^3 \times 10^6$	% of Total	Country	Quantity $m^3 \times 10^6$	% of Total	Country	Quantity $m^3 \times 10^6$	% of Total
1	US	35.79	20.2	US	33.84	16.0	US	34.35	14.2
2	USSR	25.05	14.1	Japan	26.90	12.7	USSR	21.49	8.9
3	Japan	14.83	8.4	USSR	23.35	11.1	China	18.29	7.5
4	China	7.93	4.5	China	10.59	5.0	Japan	18.12	7.5
5	France	7.87	4.4	France	8.61	4.1	Brazil	14.30	5.9
6	Australia	7.51	4.2	Brazil	7.70	3.6	India	12.53	5.2
7	Brazil	5.64	3.2	Australia	7.41	3.5	France	9.04	3.7
8	W. Germany	5.17	2.9	Romania	5.82	2.8	Australia	5.90	2.4
9	Romania	4.84	2.7	W. Germany	5.33	2.5	Canada	5.66	2.3
10	India	4.16	2.3	India	5.18	2.4	Romania	5.25	2.2
	Sub-total	118.79	67.0		134.73	64.0		144.93	60.0
	Total World Consumption	177.27			211.21			242.60	

1/ Includes non-coniferous sawlogs and veneer logs; excludes ASEAN countries.

*Adapted from FAO, Yearbook of Forest Products, various issues.

As in the case of hardwood logs, the ten largest consuming nations of plywood during the 1964 to 1981 period were mainly the affluent countries like the US, Japan, Canada, USSR, UK and West Germany (Table 2.4). For a span of eighteen years these ten countries consumed more than 80 percent of world total plywood consumption, and available data tend to indicate that their share of world total has remained close to that level during the last four years. Except for the replacement of one or two countries by other countries, the composition of the top ten consuming countries remained almost unchanged over the period under review. It is worthwhile to note the dominant role of the United States which accounted for more than 40 percent of the world total, supporting the early observation concerning the geographical pattern of trade in hardwood plywood.

The major markets for hardwood logs and plywood have been identified above, although the analysis of consumption trends has not reflected the importance of South Korea as a huge market for hardwood logs. In the next subsection, world production and prices of forest products, including the primary producing countries, will be examined.

World Production and Prices of Forest Products

World production of selected forest products from 1964 to 1981 is shown in Table 2.5. In 1981, world production of logs was 804 million cubic meters (roundwood equivalent), of which 70 percent was softwood logs and the balance hardwood

Table 2.4. Largest Consumers of Plywood in 1964, 1971 and 1981*

	1964			1971			1981 1/		
Rank	Country	Quantity $m^3 \times 10^6$	% of Total	Country	Quantity $m^3 \times 10^6$	% of Total	Country	Quantity $m^3 \times 10^6$	% of Total
1	US	12.43	55.7	US	18.29	49.9	US	15.59	41.8
2	Japan	2.09	9.4	Japan	7.07	19.3	Japan	7.03	18.8
3	USSR	1.53	6.9	Canada	1.94	5.3	Canada	1.92	5.1
4	Canada	1.30	5.8	USSR	1.87	5.1	USSR	1.71	4.6
5	W. Germany	0.64	2.9	W. Germany	0.76	2.1	UK	0.97	2.6
6	France	0.45	2.0	France	0.70	1.9	W. Germany	0.76	2.0
7	Italy	0.28	1.3	Brazil	0.40	1.1	Brazil	0.71	1.9
8	Brazil	0.19	0.8	Italy	0.39	1.1	France	0.61	1.6
9	Poland	0.16	0.7	China	0.36	1.0	South Korea	0.53	1.4
10	Czechoslovakia	0.15	0.7	Poland	0.23	0.6	Italy	0.52	1.4
	Sub-total 2/	19.22	86.0		32.01	87.0		30.35	81.0
	Total World Consumption	22.31			36.62			37.33	

1/ Includes blockboard

2/ May not add up due to rounding

*Adapted from FAO, Yearbook of Forest Products, various issues.

Table 2.5 Recorded Change in World Output of Selected Forest Products, 1964-1981*

Forest Products	Million units[1]	1965[2]	1968[2]	1971[2]	1974[2]	1977[2]	1980[2]	1981	Change 1965 - 1981		
									Volume	Index	1964 - 1981
										1965 = 100	% per year[5]
Logs[3]	m^3(r)	691.2	721.9	776.9	794.1	854.6	852.2	804.0	112.8	116	0.77
Hardwood	m^3(r)	180.1	194.7	215.1	228.0	241.7	249.2	241.9	61.8	134	1.81
Softwood	m^3(r)	511.1	527.2	561.8	566.1	612.9	602.9	562.1	51.0	110	0.37
Sawnwood[4]	m^3(s)	372.2	391.9	419.4	421.6	440.4	432.1	415.2	43.0	116	0.68
Hardwood	m^3(s)	82.4	88.8	96.1	99.8	103.9	109.4	107.7	25.3	131	1.68
Softwood	m^3(s)	290.8	303.1	323.3	321.8	336.5	322.9	307.5	16.7	106	0.37
Veneer Sheets	m^3(s)	2.1	2.9	3.2	3.7	4.3	4.5	4.5	2.4	214	5.54
Plywood	m^3(s)	24.1	29.1	36.7	37.5	40.7	39.8	37.9	13.8	157	3.17

1/ r means figures are given in solid volume of roundwood (or roundwood equivalent) without bark; s reflects figures given in solid volume.

2/ Three year averages of 1964-66, 1967-69, 1970-73, and so on.

3/ Includes sawlogs, veneer logs and logs for sleepers.

4/ Includes sleepers

5/ Computed using geometric mean formula, i.e., $GM = \left[\sqrt[n-1]{\frac{\text{Production at end of period}}{\text{Production at beginning of period}}} \right] - 1 \times 100$

*Adapted from FAO, Yearbook of Forest Products, various issues.

logs. Actually, apart from pulpwood, logs are the most important category of woods in unprocessed form. As is evident from Table 2.5, the largest increase in absolute volume between 1965 and 1981 occurred in the log category, with hardwood logs having the greatest increase. The rate of growth of hardwood log production (1.81 percent per annum) was well above that of softwood logs and also of the total logs. For the developing countries, the increasing proportion of hardwood logs in world log production and consumption is very important. This is so because tropical hardwood logs, which are produced entirely in developing countries, accounted for much of the growth in total hardwoods.

As stated, world production of hardwood logs increased by an average compounded rate of 1.81 percent per annum from 1964 to 1981, though the year-to-year production levels have shown erratic trends. Hardwood log production grew steadily until 1971, but increased substantially in 1972 by 4.5 percent over their levels a year earlier and continued to rise in 1983. The peak was reached first in 1973 (approximately 241 million cubic meters) as demand remained strong. The oil shortage in 1973-74 had a corresponding impact on world production, as much as on the world economy, which was fully felt in the subsequent years, with the construction and other wood-based industries strongly affected. This created an inflationary effect on world prices of forest products, while at the same time served to depress world demand for these commodities. As a consequence hardwood log production fell temporarily but drastically in 1974 and 1975. Fortunately, the effect of the OPEC's oil embargo was short-lived. Demand for forest products in general - and hardwood logs in particular - started to pick up in the last few months of 1975, carrying prices with it. Similarly, production of hardwood logs started to gain momentum during this period. Beginning in 1976, its production exhibited an upward trend and in 1980 it recorded the highest production level (about 255 million cu m). However, the years 1981 and 1982 brought another depressing effect on log production as a result mainly of the unhealthy condition of the building industry in the developed countries. The production trends after 1972 almost followed the fluctuations in hardwood log prices (Figure 2.4). But the increase in hardwood log prices has been significant between 1972 and 1980, although the price level fell sharply in 1981 and has remained stable in 1982. The log prices in the last two years reflected the depressed state of the international market. Simula, citing FAO's review of world trade in selected commodities, reports that: "During the last recession tropical forest products experienced a better relative price stability than before suggesting the reduction in supply may have approximately balanced the lower demand."[34]

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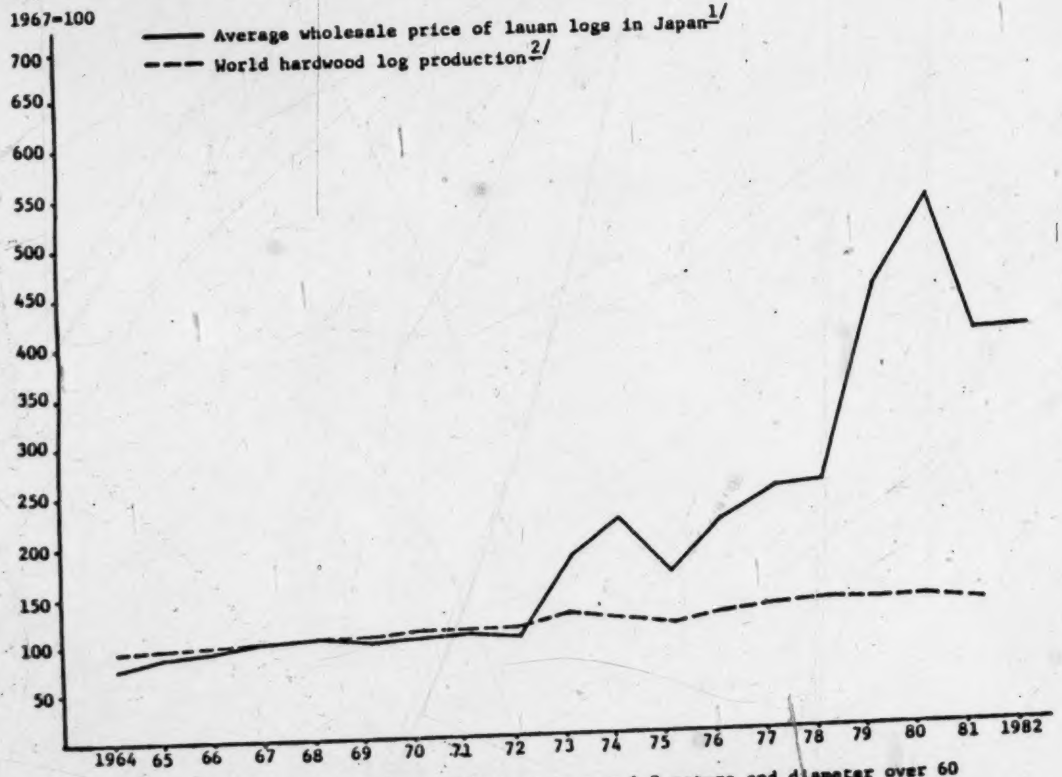
[34] M. Simula, Development of the Demand for and Marketing of Forest Products, Paper presented in the Ninth World Forestry Congress, July 1-12, 1985, Mexico City, p. 11. See also FAO, *Commodity Review and Outlook 1983-84*, FAO Economic and

Figure 2.4 Trends in Hardwood Log Production and Prices, 1964-82



Notes: 1. Lauan for plywood and veneers, length over 6.0 meters and diameter over 60 centimeters. Data were taken from Japan Economic Journal, various issues.

2. Data were taken from FAO, Yearbook of Forest Products, various issues.

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[34] (cont'd) Social Development Series No. 29, Rome, 1984.

The reduced hardwood log production following 1980 was also partly caused by the reduction in production in the developed countries, and some important producing regions (the ASEAN in particular). Factors affecting production tend to differ between developed and developing countries. Producers in the developed regions do respond to changes in demand and prices (of inputs and outputs) usually at shorter lags due to better medium of information dissemination. On the contrary, the producers in less affluent regions tend to be influenced heavily in their decisions by changes in input prices and less likely by (and normally over a longer adjustment period) changes in demand and output prices. One major reason for this seemingly delayed response in demand and output price changes is the unavailability of appropriate information at an appropriate time. Part of this information problem is the question concerning the factors influencing demand in foreign markets. Another reason involves the higher cost of production and maintenance of under- or unutilized equipment which serves as a pressure for log producers to optimize the use of equipment and sell whatever volume is produced.

Production of hardwood logs is more dispersed geographically than is the case of consumption. In 1980 the major tropical log producers have included Malaysia, Indonesia, Brazil, China, India and the Philippines. The United States, USSR, France and Australia have been the primary producers of temperate hardwood logs in the same year. These ten countries accounted for more than 60 percent of the world total (of about 255 million cubic meters) in 1980 (Table 2.6). It appears that the major source of tropical logs in international markets originated mainly from the ASEAN region (notably Indonesia, Malaysia and the Philippines) given the log export ban policy in Brazil and large domestic markets in China and India. During the year under review, 24.3 percent of the world production (in volume) and 36.4 percent of the aggregate production of the top ten producing nations was attributed to the ASEAN countries.[35]

Turning to production trends in processed wood products, the rate of growth in plywood production (3.17 percent per annum) was indeed remarkable; this growth rate was several times faster than sawnwood although slower than veneer sheets (Table 2.5). However, veneer sheets in most cases are, in turn, used as input in the production of plywood and other panel products. The general trends of plywood production and prices were very similar to those of hardwood logs during the period from 1964 to 1981 (see Figure 2.5) and hence will not be discussed in detail.

Annual plywood production has fluctuated within the range of 22.27 to 42.32 million cubic meters, with an arithmetic annual average of 34.63 million cubic meters.

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[35] Log production in Thailand is not reflected in Table 2.6 but is added in the computation for the ASEAN share in world production and in the aggregate production of the top ten producing nations. Thailand's hardwood log production in 1980 was 2.544 million cu m as reported by FAO, *Yearbook of Forest Products 1970-1981* (1981), p. 127.

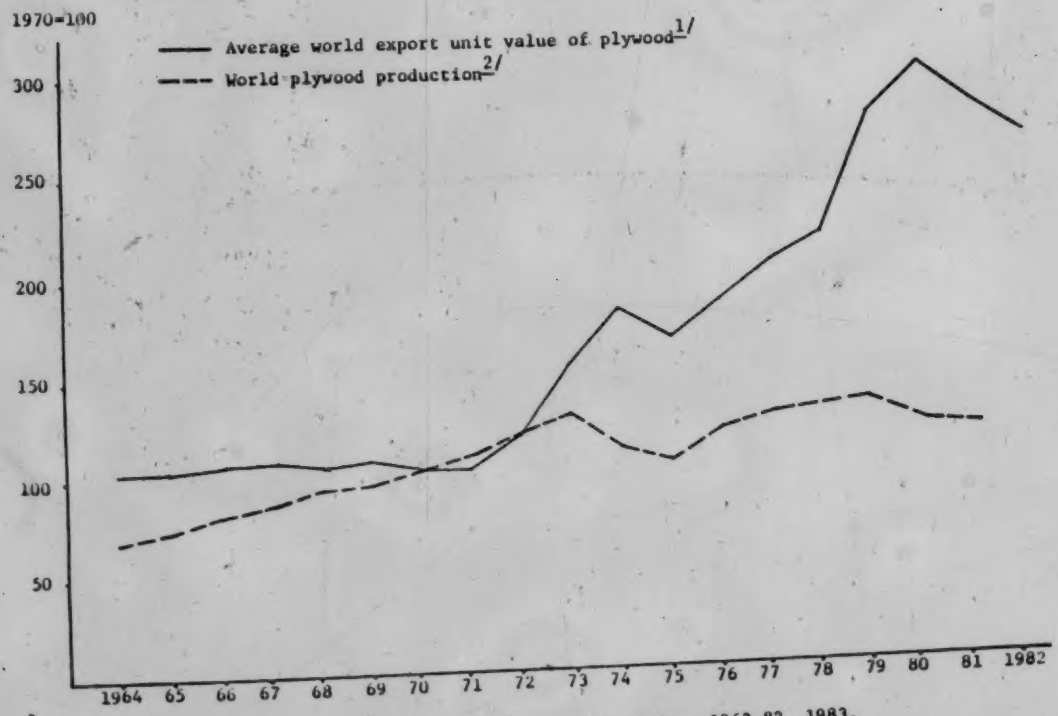
Table 2.6. Major Producers of Hardwood (NC) Logs and Plywood, 1980*

RANK	Plywood			Hardwood (NC) Logs		
	Country	Quantity $m^3 \times 10^6$	% of Total	Country	Quantity $m^3 \times 10^6$	% of Total
1	US	16.00	39.7	US	37.24	14.6
2	Japan	8.40	20.9	Malaysia	31.47	12.3
3	Canada	2.34	5.8	Indonesia	21.70	8.5
4	USSR	1.99	4.9	USSR	21.30	8.3
5	South Korea	1.57	3.9	Brazil	14.29	5.6
6	China	1.56	3.9	China	13.75	5.4
7	Brazil	0.76	1.9	India	12.54	4.9
8	Finland	0.64	1.6	France	8.38	3.3
9	Philippines	0.55	1.4	Philippines	6.21	2.4
10	France	0.55	1.4	Australia	5.79	2.3
	Sub-total[1/]	34.36	85.3		172.67	67.7

[1/] May not add due to rounding.

*Adapted from FAO, Yearbook of Forest Products, 1981.

Figure 2.5 Trends in Plywood Production and Prices, 1964-82



Notes: 1. Data were taken from FAO, Forest Product Prices 1963-82, 1983.

2. Data were taken from FAO, Yearbook of Forest Products, various issues.

Much of the increase in production in recent years has occurred in the less affluent regions, with the ASEAN region dominating. Over the 1964 to 1981 period, plywood production in the ASEAN countries grew at an average annual rate of nearly 16 percent. This rate was slightly higher than Latin America's 14.8 percent and approximately three times more than that of Africa (5.3 percent). The average production growth rate in the developed regions was more stable throughout the period (2.3 percent per annum) and slightly lower than the world average of 3.2 percent per annum.

Despite the upward trend in plywood production in the developing countries, their total output was much smaller than those of the developed countries. As in 1980, about 75 percent of world production has taken place in the US, Japan, Canada, USSR, Finland and France, while the four major producers in the developing countries (South Korea, Brazil, China and the Philippines) have accounted for only 11 percent (Table 2.6). Overall production fell by about 7 percent in 1982 compared with 1981 but most markedly in the United States and Canada where output declined by 16 percent. In the case of tropical hardwood, production in 1982 has kept at the same level as in 1981. The drop in housing activity in the US and Japan has caused the reduction in plywood production in many producing coutries which considered the two countries as major markets for the product. Variation in residential and construction activities in the US, Japan and several Western European countries has a marked impact not only in the production aspect of plywood but also its demand. Imports of plywood of these countries have generally reflected the condition in the construction industry. The United States imports, for instance, dropped by 25 percent in 1982 due primarily to the collapse of the rate of housing starts during the time. There is reason, therefore, to expect that demand for plywood imports in the major importing countries will rise with expansion in building construction. The general trend in forest products trade will be reviewed below.

Trends in World Trade

The data on forest product trade flows (see Table 2.7) clearly indicate that international trade in wood commodities has increased markedly between 1950 and 1976 and there has been enough evidence that the general trend is increasing,[36] despite the short periods of decline in the mid-seventies and in the first three years of the eighties. However, as Sedjo and Radcliffe[37] point out, the increase in trade was not symmetrical across products and across regions. In Table 2.7, it is apparent that most of the traditional products such as newsprint, pulp, pulpwood and sawnwood have grown very slowly compared to particleboard, plywood and sawlogs. The latter three commodities' world traded volumes in 1976 have increased in excess of 1000

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[36] K. Takeuchi, op. cit., pp. 440-443.
[37] R. A. Sedjo and S. J. Radcliffe, *Postwar Trends in US Forest Products Trade, A Global, National and Regional View*, (Washington, D.C. : Resources for the Future, 1980), p. 27.

Table 2.7. World Forest Product Trade Flows, 1950 and 1976

PRODUCT	Year 1950	 1976	1976 as a percentage of 1980
	$m^3 \times 10^3$		
Solid wood			
Sawlog, conifer	2 670	28 420	1 064.4
Sawlog, nonconifer	2 750	43 419	1 578.9
Pulpwood	6 850	15 886	231.9
Sawnwood, conifer	21 420	53 639	250.44
Sawnwood, nonconifer	3 050	10 212	334.8
Veneer sheets	155	1 382	891.6
Plywood	406	6 257	1 541.1
Particleboard[a]	128	4 494	3 510.9
Fiberboard	392	1 979	504.8
Total Solid Wood	37 821	165 688	438.1[b]
Fiber			
Paperboard	1 945	15 866	815.7
News print	5 540	10 746	194.0
Pulp	5 730	16 358	285.5
Total Fiber	13 215	42 970	325.5[c]

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a/ Particleboard data reflect 1959 data since earlier data are unavailable.

b/ Average compounded rate = 5.8 percent per annum.

c/ = 4.87 percent per annum.

Source: Sedjo, R.A. and S.J. Radcliffe, 1980, p. 28.

percent of their 1950 traded levels.[38] Moreover, this asymmetry in trade (across products and regions) is also evident with the data on consumption and production of hardwood logs and plywood that were presented earlier. In line with this observation, Bethel and Schreuder suggest "that as a general rule, major producing countries tend also to be major consumers of forest products." [39] There are at least two interrelated factors that allow this to happen : first, due to "the pervasive characteristic of forest geography," and second, "the fact that wood is very bulky and relatively low-value material that is expensive to transport great distances." [40]

Between 1964 and 1981 world exports of selected major forest products[41] increased from US $3.52 billion to US $21.76 billion, an average rate of about 11 percent per annum. This rate was at par with the growth of total world trade in all commodities during this period. But the essential point in almost two decades of trade in forest products has been the surprising increased exports by developing countries, which in recent years have surpassed their imports. Exports of selected major forest products from these countries grew at an average annual rate of 13 percent - higher than that of world exports - from US $705 million in 1964 to US $5.78 billion in 1981. This growth was two percent faster than the corresponding exports of developed countries and four percent above growth in centrally planned economies.

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[38] Ibid, p. 29.

[39] J. S. Bethel and G. Schreuder, "The Product Mix and Flow of Wood Materials in International Trade," in J. S. Bethel (ed), (1983), pp. 287-315.

[40] Ibid, p. 302.

[41] Referring to broad product categories of roundwood, sawnwood, and wood-based panels.

The bulk of developing countries' exports have been in unprocessed form, with hardwood logs accounting for about 46 percent in 1981 (Table 2.8). On the other hand their imports consisted largely of products that have undergone a high degree of processing. This suggests that developing countries ~~can~~ benefit more if improvements can be made in their processing capabilities and marketing strategies. Increasing the production of processed products will help reduce their imports to meet domestic requirements and also enable them to transport these (processed) products over much longer distances at reasonable costs relative to product prices.

As illustrated in Table 2.8, exports of developed countries still dominate the trade scene, accounting for nearly 60 percent (or US $12.76 billion) of world total forest products exports in 1981.

In the case of hardwood logs, world exports (in value terms) increased from US $476.7 million in 1967 to US $3004 million in 1981. In volume terms, these exports grew from 19.9 to 33.4 million cubic meters for the same period (with an arithmetic average of 37.4 million cubic meters per annum). World import value also expanded during the period from US $663.4 million to US $4447.4 million; while the

Table 2.8. Trade of Selected Forest Products, 1981 (in million US \$[1])*

Product Group	World[2]		Developed Market Economies		Centrally Planned Economies		Developing Market Economies	
	Export	Import	Export	Import	Export	Import	Export	Import
Roundwood	6 894	9 076	2 995	7 206	1 092	776	2 807	1 094
Logs[3]	4 945	6 887	1 620	5 229	608	716	2 717	943
Softwood	1 941	2 440	1 296	2 146	583	115	62	179
Hardwood	3 004	4 447	325	3 083	25	600	2 655	764
Sawnwood	10 051	11 211	6 994	8 717	1 432	1 403	1 624	1 869
Wood-based panels	4 819	4 903	2 773	3 717	698	243	1 348	943
Plywood[4]	2 737	2 575	1 106	1 846	540	58	1 091	670
All products[5]	21 764	25 190	12 762	19 640	3 222	2 422	5 779	3 906

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[1] Exports in f.o.b. values, imports in c.i.f. values.

[2] Figures for both exports and imports may not add for the three economic classes due to rounding

[3] Include sawlogs, veneer logs and logs for sleepers

[4] Includes blockboard

[5] All products refer to roundwood, sawnwood and wood-based panels

*Adapted from FAO, Yearbook of Forest Products, 1981.

total imported volumes increased steadily from 18.9 to 40.0 million cubic meters. Investigation of the year to year flow of hardwood logs indicates that the major exporters were the predominantly less affluent countries, such as the ASEAN countries, Ivory Coast and Gabon, while the high income countries were mostly the largest importers (Table 2.9). Between 1970 and 1981, for instance, the top ten exporters include only one or two developed countries as compared to three or four developing countries in the ten leading importers of hardwood logs. It may be worth noting that during this period the ASEAN exports ranged from 67 to 70 percent of world total hardwood log exports.

World plywood exports rose from US $437.02 million in 1967 to US $2.74 billion in 1981, while imports surged from US $446.26 million to US $2.58 billion over the same period. Trade in plywood has been concentrated in both developed and developing market economies. In 1981 each market economy accounted for 40 percent of world export. The remaining twenty percent was accounted for by the centrally planned economies such as USSR and Romania (Table 2.8). South Korea topped the list of the ten major world exporters between 1970 and 1981, while the US and UK led the top ten importing countries (Table 2.10). The ten major exporting countries accounted for 70 to 80 percent of world total as compared to 65 to 80 percent of the aggregate plywood imports of the ten leading importing countries.

Table 2.9. Largest Importers and Exporters of Hardwood (NC) Logs, 1970 and 1981*

	IMPORTS						EXPORTS					
	1970			1981			1970			1981		
Rank	Country	Quantity $m^3 \times 10^6$	% of Total	Country	Quantity $m^3 \times 10^6$	% of Total	Country	Quantity $m^3 \times 10^6$	% of Total	Country	Quantity $m^3 \times 10^6$	% of Total
1	Japan	19.85	55.0	Japan	14.37	42.3	Malaysia	11.35	29.4	Malaysia	15.85	47.5
2	South Korea	2.89	8.0	China	4.40	12.9	Philippines	8.62	22.3	Indonesia	6.22	18.6
3	Italy	1.91	5.3	South Korea	3.54	7.5	Indonesia	6.06	15.7	Ivory Coast	2.34	7.0
4	Singapore	1.84	5.1	Italy	1.21	3.6	Ivory Coast	2.51	6.5	Philippines	1.44	4.3
5	W. Germany	1.70	4.7	France	1.13	3.3	Gabon	1.63	4.2	Gabon	1.10	3.3
6	France	1.53	4.2	W. Germany	0.84	2.5	Ghana	0.76	2.0	France	0.81	2.4
7	Spain	0.72	2.0	Hong Kong	0.83	2.4	Cameroon	0.51	1.3	Papua N G	0.75	2.2
8	Belgium Lux.	0.44	1.2	Singapore	0.75	2.2	Congo Pop Rp	0.43	1.1	US	0.71	2.1
9	Netherlands	0.40	1.1	Spain	0.42	1.2	Nigeria	0.22	0.6	Cameroon	0.67	2.0
10	Hong Kong	0.40	1.1	Canada	0.17	0.5	Paraguay	0.17	0.4	Liberia	0.49	1.4
	Sub-total[1/]	31.68	87.7		27.66	81.4		32.26	83.4		30.37	91.0
	WORLD TOTAL	36.11			34.00			38.66			33.36	

1/ May not add due to rounding.

*Adapted from FAO, Yearbook of Forest Products, 1970 and 1981.

Table 2.10. Largest Importers and Exporters of Plywood, 1970 and 1981*

	IMPORTS						EXPORTS					
	1970			1981			1970			1981		
Rank	Country	Quantity $m^3 \times 10^6$	% of Total	Country	Quantity $m^3 \times 10^6$	% of Total	Country	Quantity $m^3 \times 10^6$	% of Total	Country	Quantity $m^3 \times 10^6$	% of Total
1	US	1.771	37.7	US	1.028	16.0	South Korea	0.822	18.3	South Korea	1.068	15.2
2	UK	1.101	23.4	UK	0.784	12.2	Finland	0.602	13.4	China	0.868	12.4
3	W. Germany	0.214	4.5	Saudi Arabia	.473	7.4	Canada	0.369	8.2	Singapore	0.587	8.4
4	Netherlands	0.150	3.2	Singapore	0.412	6.4	Japan	0.322	7.2	Indonesia	0.535	7.6
5	Canada	0.131	2.9	Hong Kong	0.390	6.1	USSR	0.281	6.3	Finland	0.520	7.4
6	France	0.096	2.0	Belgium Lux	0.277	4.3	Philippines	0.256	5.7	Malaysia	0.469	6.7
7	Denmark	0.078	1.7	W. Germany	0.267	4.2	US	0.115	2.6	US	0.437	6.2
8	Sweden	0.068	1.4	Netherlands	0.233	3.6	France	0.100	2.2	Canada	0.408	5.8
9	Belgium Lux	0.062	1.3	Japan	0.154	2.4	Italy	0.098	2.2	Philippines	0.408	5.8
10	Singapore	0.056	1.2	France	0.122	1.9	Gabon	0.081	1.8	USSR	0.324	4.6
	Sub-total 1/	3.727	79.3		4.140	64.5		3.046	70.0		5.624	80.2
	WORLD TOTAL	4.70			6.42			4.48			7.01	

1/ May not add due to rounding.

*Adapted from FAO, Yearbook of Forest Products, 1970 and 1981.

The preceding discussions provided an overview of the patterns of consumption, production and trade in forest products. Some of the important points emerging therefrom can be summarized as follows. First, developed countries in general have larger consumption than developing countries in absolute terms, although the latter have exhibited large annual increases in consumption. Both in the developed and developing countries, consumption appears to be directly related with economic growth. Increases in population in the developing regions also contributed in the rising rate of consumption and represent a big demand potential for forest products. The effect of economic and population growth would be either a change in the desired stock of houses per capita or an increase in housing construction per capita. However, in both cases there would be an increase in demand for wood products. World consumption of wood-based panels has shown an increasing trend during the period 1970-80, while consumption of industrial roundwood, sawnwood and sleepers decreased. A continuing upward trend in wood-based panels consumption would no doubt create additional demand for these products and this information is important to the log-producing countries which aim to stimulate exports of value-added products. Within the industrial roundwood category, however, hardwood log consumption trended upward throughout the period under review. Secondly, production of hardwood logs grew faster than that of softwood logs from 1964 to 1981. The ASEAN countries accounted for the bulk of tropical hardwood log production. Similarly, plywood production showed a rising trend although this has largely taken place in the most affluent countries. The most striking feature with respect to plywood production was the active participation of the Asian in-transit processing countries, notably South Korea and Taiwan. Finally, trade in sawlogs, plywood and particleboard has increased in a very rapid pace. Japan, South Korea and Taiwan (China) were (and still are) the major hardwood log importers, with the ASEAN countries serving as the main suppliers. The major markets for hardwood plywood were the United States and West European countries. Hardwood plywood originated mostly from South Korea, Taiwan (China), the ASEAN countries, Japan, Canada and Finland. Moreover, this section reveals some factors that tend to affect demand for forest product imports such as the level of construction activity and relative price of wood imports.

These observations also strengthen the choice of markets to be analyzed in this study. The United States is no doubt the largest market for tropical hardwood plywood. It is therefore not surprising that both Japan and South Korea remained strong markets for tropical logs for conversion into plywood and other processed products - the former primarily for domestic consumption, while the latter for re-exportation to other countries, mainly the United States. A more detailed analysis of Japan, South Korea and the United States is presented in the next section.

E. Analysis of Primary Markets for Hardwood Logs and Plywood

Import demand for hardwood logs and plywood in foreign markets depends to a great extent on the type of consumers to whom the products under consideration appeal most or the sectors using the products. As a result, the dominant wood using sectors tend to influence the product structure and quantity requirements of demand in a foreign market. Following is a discussion describing the major wood using sectors in Japan, South Korea and the United States. In addition, this section will attempt to identify factors governing import demand for the products in question, and examine trends in import demand and domestic supply, including market institutions.

Japan -- World's Largest Log Market

Japan is reliant on second growth forest, which makes it difficult to harvest large size logs required in the manufacture of veneer and plywood. Furthermore, the need to increase the public functions of the forest,[42] the high cost of plantation development and the steep terrain of available forest lands,[43] made Japan dependent on foreign supply to meet domestic requirements. The proportion of imported timber required to satisfy domestic demand increased from a mere 11 percent in 1960 to 50 percent in 1969, 64 percent in

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[42] Japan External Trade Organization, *Japanese Forestry and Forest Products Trade* (Revised), Tokyo, Japan (1983), p. 1.
[43] Japan Forest Technical Association (ed.), *Wood Supply and Demand in Japan*, (Published by Nippon Mokuzai Bichiku Kiko 1982), p. 49.

1973 and 69 percent in 1979.[44]

Demand for forest products import in Japan is heavily dependent on the trends of building and construction industries, the major end user of wood products. Within these industries, the housing industry appears to be the most important as import demand tends to fluctuate directly with the growth rate of housing starts. During the period of high economic growth, housing construction expanded substantially with consequent positive effect on import demand. Thus the above timber import trend has moved along with the number of housing starts, which rose from 500,000 units in 1960 to 1.91 million units in 1973 and 1.5 million units in 1979.[45] On the other hand, housing construction is influenced by the general economic conditions and money supply (i.e., loans). The contraction in the activity of the industry in the early 1980s was due mainly to increased house prices and costs of factor inputs, such as labor, capital, land and building materials. This situation has been compounded by reduced population movements, lower number of marriages and low exchange rate of yen.[46] All these factors affecting the industry also affect demand for forest product imports. The effects of increased house and input prices could lead to input mix adjustment or input substitution due to price and scale changes. Shifting population and family formation could have either of two effects on import demand which are reflected through the demand for housing. If new households have the same income and preferences as those already in that place, the result would be merely an increase in demand for housing. However, if the new households have higher income and different preferences, the demand for housing will be accompanied by more specific requirements on the inputs used to produce houses. In any case, there will always be a rise in demand for inputs, including the imported product. But the second case has the effect of likely changes in product structure and quality requirements of demand for the forest product imports. Falling exchange rate of the yen tends to depress import demand.

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[44] Japan External Trade Organization (1983), p.4; and Japan Forest Technical Association (1982), p.66. As a matter of fact, wood and wood products ranked third among commodities imported by Japan, after petroleum and foodstuffs, in 1976. For this, see A. Takahashi, et al., "Recent Trends in the Wood Industry of Japan," *Forest Products Journal*, 30(1980): 29.

[45] Data on housing starts were taken from Japan External Trade Organization (1983), p. 5; and Japan Forest Technical Association (1982), p. 36.

[46] Japan Forest Technical Association, op. cit., p. 36-37.

Two major trends in housing construction have become visible in recent years which have implications on import demand. Firstly, the ratio of wood input to the total building materials consumed annually is declining. For instance, the share of wood input dropped from 70 percent in 1970 to 58 percent in 1982.[47] The industry seems to be moving towards flexibility in input use as it begins to use some substitute materials. The presence of increasing substitutes such as steel and aluminum reduces the optimum requirements in lumber demand. The result of substitution effect will be reflected in the quantity demanded of each input. Factor substitution, however, may also be due to increasing scarcity of some inputs relative to the others. Secondly, there is a general trend towards expansion of floor area per unit although it will not likely increase the proportion of wood in the total inputs.

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[47] Japan External Trade Organization, op. cit., p. 5.

The supply of roudwood and wood products in Japan comes mainly from the ASEAN countries for hardwoods and the United States, Canada, USSR and New Zealand for softwoods. Of its total wood imports[48] in 1981, 47 percent were from North America, 28 percent from tropical countries (mainly the ASEAN countries), 10 percent USSR and 3 percent New Zealand. The balance was accounted for by other supplying countries. Logs made up the bulk of its imports. In 1981, the volume of log imports was 35.93 billion cubic meters (or 59.3 percent of total forest products imported) amounting to US $3.67 billion. Plywood imports was minimal, reaching only 122 million cubic meters and amounting to US $11 million.[49] In terms of tropical hardwood imports, logs also dominated the trade scene and this was estimated to be 90% of all tropical timber coming into Japan[50] in 1983. Most of the solid softwoods are processed into lumber, while tropical hardwood logs are used predominantly in plywood production. Supplies of hardwoods and softwoods appear to be influenced by the availability of these products in the producing countries, by the prices of the products and by the costs of timber production. In theory, the interaction of demand for and supply of a given product determines the equilibrum price and quantity of that product, in the absence of any trade barrier, which are acceptable to the traders involved. In reality, this does not seem to exist. Aside from the presence of trade restrictions, some producers have little bargaining power than importers or foreign consumers. One consequence of the latter is that the price of the supplied product is determined in the importing countries by international competition. On the other hand, the availability of the product in the supplying countries tends to result in inelastic supply in the short run;[51] an example of this is the log supply from Indonesia and Sarawak (Malaysia) prior to 1980.

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[48] Referred to as "lumber imports" but represented the total imports of logs, sawtimber, plywood, veneer, chips, pulp, etc., all converted to logs, as reflected in Table 14 of the report by the Japan External Trade Organization (1983) p. 11.

[49] Ibid, Table 10, p. 9; Table 13, p. 11.

[50] J. Turbang, op. cit., p. 27.

The prospects for wood imports in Japan remains robust. Despite reports that housing demand will very likely stabilize and domestic supply situation will tend to improve in the future -- expected to be 46.2 million cubic meters in 1986, 57.7 million cubic meters in 1996 and 87.9 million cubic meters in 2006 --wood imports will still form an important part of its total supply.[52] Total imports are estimated to be 72.2 million cubic meters in 1986 and in 1996, 75.5 million cubic meters. It can be expected that the housing industry will remain the driving force behind the projected wood import increases due to lack of substantial growth in other wood using sectors. However, the proportion of processed products in the estimated total imports is uncertain. Future import demand by the housing industry is expected to reflect the changing lifestyles and housing preferences, the effects of the presence of substitute and fire-resistant construction materials, and the housing regulations.

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[51] Joint CTC/ESCAP Unit on Transnational Corporations, *Transnational Corporations and the Tropical Hardwood Industry of Indonesia*, UN Economic and Social Commission for Asia and the Pacific, Working Paper No. 16, Bangkok, 1981, p. 11.

Japan has a distinct trade structure especially in the importation of forest products. Mori[53] characterizes Japanese trade structure as oligopolistic because 12 General Trading Firms (GTFs) control 80 percent of North American timber imports. The same structure applies to the handling of ASEAN products, logs in particular. In 1978, about 70 percent of logs imported from the ASEAN region were handled by only 15 major GTFs (i.e., Marubeni, Nissho Iwai, and Mitsui) with the balance distributed among some 90 smaller firms.[54] These GTFs serve as the (traditional) link between the producers and users in Japan, but also seem to play a dominant role in the trade within the country. The structure and distribution channels of trade in forest products in Japan have been well presented in the "End Use Survey of ASEAN Wood Products : 1981 Report."[55] Turbang highlights the significant trends in Japan's timber trade :

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[52] See Japan External Trade Organization, op. cit., Table 9, p. 9; JapanForest Technical Association, op. cit., p. 60; ASEAN (1981) (volume 4), Table 1, p. 14.

[53] H. Mori, "The Behavior of General Trading Companies as Reflected in Lumber Prices," *Japanese Economic Studies*, IX(1980): 3-44.

[54] ASEAN, op. cit., pp. 43-49.

> First, many middlemen are being eliminated through consolidation and direct dealing. Manufacturers and large wholesalers are selling directly to ... construction firms, thus by-passing the traditional retailers. The second change ... instituted by the major trading companies themselves - ... build the necessary plant facilities, supply logs and lease the facilities to processors; ... then buys the processed products and sells to wholesalers, distributors, and retailers ... Thus the GTC *(or GTFs)* can control the log supply, the market for the producer, and some of the distribution channels.[56]

While bypassing and forward integration have characterized the above changes, the GTFs have likewise started vertical (backward) integration to ensure wood supply. Through joint ventures with the log producing countries, the GTFs transfer the processing facilities overseas and bring into the country processed products produced externally by their own producers. Another measure being undertaken is the development of lathes and dryers which can handle small diameter and lower quality logs, as well as improving the industry's capability to use softwood logs.

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[55] Ibid, Figures 4 to 6, pp. 46-48.
[56] J. Turbang, op. cit., pp. 48-49. Italics provided.

South Korea -- A Major Hardwood Log Market

Officially called the Republic of Korea, this country has an extensive forested area estimated to be about 67 percent of total land area (of approximately 9.88 million hectares) in 1977, although the ratio of forest area per capita is only 0.18 hectare with relatively poor growing stock per hectare (about 16.3 cubic meters per hectare).[57] Sharing the fate of other developing countries, one of its major forest problem is the massive and incautious fuelwood collection activities of villagers that causes the fast deterioration of the forest. All these factors, including the country's rapid economic development and population growth rate, prompted forest products industries in South Korea to depend on the supply available in the log-producing countries.

The main source of demand for log imports in this country is the plywood manufacturing industry which has attained a reputation in world wood economy for its highly efficient production system. For the period 1962-76, South Korean plywood industry has been "fourth or fifth in the world production and first in the export market."[58] At present, South Korea still plays a major part in world hardwood plywood trade. In 1981, its recorded export of plywood was 1.07 million cubic meters which accounted for more than 15 percent of world total and nearly 19 percent of that of the ten leading exporting countries (Table 2.10). This industry is basically export-oriented in that a great bulk of its annual production is exported in the United States and other countries of final consumption. The efficiency of the plywood industry has been enhanced by relatively cheap labor input, government's export promotion policy (based on export-oriented growth strategy) which includes tariff exemptions of raw material imports for export production and financing of imports for exports.[59] and strategic locations of plywood mills. Fourteen of the 94 plywood mills are located in such harbor cities as Busan, Gunsan and Inchon[60] which account for most of the plywood produced using imported logs, where the plywood is re-exported in overseas markets. During the last two decades, the expanded production and export of plywood has led to increased demand for log imports. With logs as the basic input in plywood production, one can speculate that import demand for this product will increase as production rises.

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[57] P.W. Lee, "Economic Development of Forest Products Industries in Korea," *Forest Products Journal*, 30(1980): 16-17.
[58] Ibid.

The volume of log imports required for plywood production has been derived mainly from South-East Asian countries (i.e., Indonesia, Malaysia and the Philippines) and the Pacific Coast of Canada and the United States. In the twelve year period from 1968 to 1977, however, the imported logs used for plywood have originated largely from the ASEAN countries and this accounted for more than 60 percent of this country's total log imports during the period. This obviously implies that South Korea is a big market for hardwood logs. The industry's strong dependence on foreign log supply makes it vulnerable to supply variation. The present move of some producing countries to curb log exports will therefore affect South Korea's forest products industries, but not South Korean end users. It is likely that the plywood industry's demand for log imports is inelastic, at least in the short run, due to its high fixed overheads and the costs associated with adjustment.

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[59] Between 1952 and 1977, there were 38 different types of incentives provided by the government to promote exports in South Korea. For this, see Hong, W. *Trade, Distortions and Employment Growth in Korea* (Seoul: Korea Development Institute, 1979).

[60] P.W. Lee, op. cit., p. 17.

South Korea has a relatively small domestic market for processed products and this is being satisfied by the present production level. The three main end users of forest products include industries involved in construction, civil engineering, and mining. Between 1962 and 1977, their combined demand for 'general wood use' rose four times from 621,000 cubic meters to 2.53 million cubic meters, while that of plywood increased by 31 times from 160,000 cubic meters to 2.53 million cubic meters (or about 55 percent of total demand in 1977).[11] Most of the demand by these end users has been satisfied by domestic production (i.e., using domestically-produced timber). Much of the increase in demand for wood imports that can be expected in the foreseeable future will still come from the plywood manufacturing industry.

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[11] P. W. Lee, "Timber Demand and Forest Products Trade, Economic Development of Korean Forest Products Industries," *Forest Products Journal*, 31(1981): 13-14.

Recently, the forest products industries in general have undertaken three measures in anticipation of a complete log export ban in the ASEAN countries. These include (1) shifting "from general panel production into high quality plywood or processing custom-made products,"[42] (2) diversifying sources of imports as far as Africa and Latin America, and (3) expanding the timber base through reforestation. Domestic supply is projected to increase in the near future as a result of successful reforestation program initiated in the early sixties.

The current distribution channels in this country are less known, though it is presumed that some importers have direct links with the processors, in particular the plywood millers located in harbor areas. The export orientation of the principal user (plywood industry) of log imports may perhaps explain the less importance of distribution system in South Korea with respect to forest products trade.

The United States -- Major Market for Hardwood Plywood

During the 1970s hardwood plywood imports in the United States have grown remarkably (with the exception of 1974-75) and accounted for more than 70 percent of hardwood plywood consumed in the country throughout this decade.[43] This increase in import demand has been attributed to two major factors. First, the relatively low price of imported hardwood plywood compared with other competing construction materials, which made it possible for the residential construction industry - the main user of the imported product - to substitute the former for the latter. The demand for hardwood plywood imports, however, appears to be sensitive to import price as revealed by some recent findings. Chou and Buongiorno[44] studied the United States demand for hardwood plywood imports from South Korea, Taiwan, Japan and the Philippines and found out that it was price elastic. Their estimated own-price elasticities ranged from -1.95 for imports from South Korea to -1.77 for imports from the Philippines for the period January 1974 to December 1979. The same authors also found out that the elasticity of demand for total hardwood plywood imports with respect to its price was in the order of -1.98 and -2.20. Apparently these estimates imply a very elastic import demand for the product in question. The bulk of hardwood plywood imported by the United States originated from South Korea, Taiwan, Japan, and the Philippines, which altogether accounted for no less than 90 percent of total imports of this product until the late 1970s. In 1979, for instance, about 93 percent of the 391.8 million cubic meters of the country's hardwood plywood imports were shared by the four major supplying countries.‘'

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[42] P. W. Lee loc. cit.

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[43] See ASEAN, *End Use Survey of ASEAN Wood Products : 1981 Report, Volume 7 : the United States* 1980; J. Chou and J. Buongiorno, "United States Demand for Hardwood Plywood Imports by Country of Origin," *Forest Science*, 29(1983) :225-237, and "United States Demand for Hardwood Plywood Imports : A Distributed Lag Model," *Agricultural Systems*, 8(1982): 225-239.

[44] J. Chou and J. Buongiorno (1983), p.233.

Secondly, the number of housing starts has increased considerably. Indeed the level of imports in the 1970s seemed to reflect the trend in housing construction. Between 1967 and 1971 new housing units‘‘ constructed grew at an average annual rate of 12 percent per annum, from 1.3 to 2.1 million. By 1972, construction reached the peak of nearly 2.4 million units and then slowed down in 1973 (2.1 million units). The impact of oil crisis which has driven up the prices of almost all commodities, building materials in particular, has led to a recession in housing construction. As a result, the quantity demanded of hardwood plywood imports decreased, while the number of housing units continued to fall in 1974 and 1975 due to depressed housing demand. The trend in housing construction was revived in 1976 through 1978, reaching again the two-million unit mark during the latter year. This was followed by a sharp fall in construction activity in 1979 which lasted until 1982 as a result mainly of low economic growth. The findings of Chou and Buongiorno‘’ suggest that import demand for hardwood plywood is directly related to housing starts. In addition,

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‘'It may be worth noting that the raw materials (i.e., logs) of the hardwood plywood from these Asian countries were basically of ASEAN origin.

‘‘Refer to the total private and public units started, including farm housing.

‘’J. Chou and J. Buongiorno (1982), p.236.

they found out that the growth in imports of this product, which rose at an average annual rate of some 4.7 percent form January 1974 to December 1979, was caused predominantly by the rapid rise in housing starts.

Moreover, the inherent physical characteristics of South-East Asian hardwood, evidenced from its straight grain or uniform texture, which enhances the pleasant appearance of manufactured plywood, also add to the popularity of hardwood plywood in the United States. This product is used for interior decorative wall panelling.

Developments in domestic production of plywood and lumber have provided the construction industry an opportunity to choose an optimal input mix arising from, say, relative price changes or technical change. For instance, the advent of composite plywood, suitable for subflooring and single-layer floors, has resulted in the reduction of lumber share in residential construction in the 1970s due primarily to relative price effects. This development would likely affect (or had already affected) demand for hardwood plywood imports, depending upon its relationships with domestically-produced plywood and lumber.

The United States demand for hardwood plywood imports is projected to increase from 2.3 billion square feet (3/8 inch basis) in 1977 to 3.5 billion square feet in 1990 and by 2000, 3.7 billion square feet.'' Future import demand

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''For this, see D. R. Darr and G. R. Lindel, "Prospects for US Trade in Timber Products : Imports," *Forest Products Journal*, 30(1980): 16-20.

will possibly reflect the sensitivity of the industry to changes in import price, level of residential construction, prices of imperfect substitutes, housing regulations (i.e., fire safety regulation) and demand patterns for housing.

The market for hardwood products in the United States is not yet fully developed. One reason for this is the wide range of species that comprise the imported hardwood products which are difficult to resell to domestic buyers with varied specific requirements. The result is that importers tend to specialize in certain types of products, such as plywood, or in those which originate from certain producing areas, such as the East and South-East Asian countries. The Imported Hardwood Products Association (IHPA) acts as the trade link between producers/exporters and end users to ensure that the products brought into the United States market satisfy domestic requirements.

F. Summary and Conclusions

The purposes of this chapter have been to present the geographical direction, distribution channels and general trends of trade in forest products, particularly hardwood logs and plywood, and to analyze the primary markets (Japan, South Korea and the United States) for hardwood logs and plywood. World consumption, production and prices of forest products were also examined.

Three major inferences emerge in relation to the first purpose. First, trade in hardwood logs has been relatively more concentrated than hardwood plywood over the period from 1960 to 1982. This could be due to the bulkiness, weight and higher freight cost per unit volume of hardwood logs which contrain its wider distribution. The larger number of participants in hardwood plywood trade suggest that prospects for market expansion exist, although it requires a better understanding of the basic needs and wants of major wood using sectors in the importing countries. Knowledge of the factors affecting import demand is also needed. Second, distribution channels tend to move away from the traditional system towards channel bypassing and forward and backward integration to enhance the efficiency of forest products distribution. These structural changes offer substantial benefits both to producers and exporters as well as to importers in terms of reduced costs of distribution per unit volume of the product. Finally, the data on the trends in world wood economy reveal that trade in hardwod logs and plywood has increased considerably over time, with indications that it is going to continue to be stronger in the immediate future. Japan, South Korea and Taiwan (China) remain the major hardwood log importers, while the ASEAN countries serve as the main suppliers. However, with the current log export restriction policy in the ASEAN, it can be expected that the flow of hardwood logs from Central and West Africa towards Asia will grow, including probably the softwood log exports from North America and USSR. The major markets for hardwood plywood have been, and still are, the

United States and Western European countries.

The analysis of the primary markets indicates that the residential construction industry is the principal user of imports in Japan and the United States, while in South Korea, it is the plywood manufacturing industry. Data on imports in these countries suggest that the activities of the principal users have influenced the quantity demanded. These principal users should therefore be the focus of import demand analysis.

III. REVIEW OF RELEVANT THEORETICAL CONCEPTS AND ANALYTICAL METHODS

A. Introduction

The preceding chapters suggest that an accurate knowledge of the factors influencing the demand for forest products in the foreign markets is the key to the efficient use of the timber resources and the growth of the forest industry in the ASEAN region. A better understanding of these factors however depends greatly on the reliability of the available information and specifically on the estimates of demand elasticities which reveal the responsiveness of the demanders (end use firms in the importing countries) to economic stimuli. Unfortunately, there is not at present an agreement concerning the magnitude of demand elasticities for these products.[69] This is primarily due to differences in analytical methods, techniques, and data used; and to a certain extent to the inappropriate treatment of forest products in the basic theoretical model. Some authors[70] have utilized consumer demand theory in an attempt to establish theoretical relationships in their demand models despite the common knowledge that forest products are generally intermediate products. This approach results in the usual expression of demand function for consumer goods relating the quantity demanded to the level of (nominal or real) income and one relative price term (i.e., the ratio of the price of the good in question to the prices of other products of comparable nature). In recent literature in this area, such an approach was found to be unsuitable for an econometric study of forest sector demand[11] not only because of the basic nature of the products involved but also because of such factors as technological, institutional and other economic constraints that have major impacts on demand but cannot be generated from the underlying theory of consumer demand.

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[69] For an illustration of this point, see Table 1 in M.L. Rockel and J. Buongiorno, "Derived Demand for Wood and Other Inputs in Residential Construction : A Cost Funtion Approach," *Forest Science*, 28 (1982): 207-219.

[70] See, for example, J. Buogiorno, "Long-Term Forecasting of Major Forest Products Consumption in Developed and Developing Economies," *Forest Science*, 23(1977): 13-25; and "Income and Price Elasticities of Demand for Sawn Wood and Wood-Based Panels : A Pooled Cross-Section And Time Series Analysis," *Canadian Journal of Forest Research* , 9(1979): 141-148. For further references, see M. Simula, (1985).

Recently, with significant developments in duality theory, other authors[12] introduced the theory of derived demand in the study of forest products. The attractiveness of this approach is that it explicitly recognizes the basic nature of forest products as intermediate products and hence as one of the many inputs in the production function of the demanding firm. To show how this theory differs from the first one mentioned above, the next two sections will review both of them, with emphasis on the derived demand theory. This chapter will also present the procedure in obtaining the derived demand functions from a general cost function using the property of duality and Shephard's theorem, and discuss some relevant aspects of production technology that need to be considered in the estimation of the demand for forest products. Moreover, a discussion of the analytical methods (or models) frequently used in this area will also be made, as well as the importance of response lags in demand analysis. The latter part of the chapter will focus on the review of selected literature.

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[11] This was examined from both theoretical and econometric viewpoints in A.E. Andersson, R. Brannlund and G. Kornai, "The Demand for Forest Sector Products," in IIASA, *Proceedings of the Third North American IIASA Network Meeting*, Victoria, British Columbia, March 21-23, 1985, pp. 123-139.

[12] See H.E. Doran and D.F. Williams, "The Demand for Domestically-Produced Sawn Timner : An Application of the Diewert Cost Function," *Australian Journal of Agricultural Economics*, 26(1982): 131-149; and J.C. Nautiyal and B.K. Singh, "Using Derived Demand Techniques to Estimate Ontario Roundwood Demand," *Canadian Journal of Forest Research*, 13 (1983): 1174-1184. Refer also to Andersson et al (1985) and Rockel and Buongiorno (1982).

The theoretical framework and demand models for this particular study will be presented in the next chapter.

B. Consumer Demand Theory and Demand Functions

In consumer demand theory, consumers (either households or governments) are assumed to be rational and consistent in their decisions so that they choose the bundle of goods[73] (including services) they plan to purchase that maximize their utility, subject to budget constraints. Such a budget constraint implies that consumers' total expenditures on all goods have to equal their income. Utility, in this context, corresponds to the satisfaction which a consumer derives as a result of consuming or possessing a particular commodity bundle.

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[73] The terms goods, products and commodities are synonymous and are used interchangeably in this section. In section C, products are meant synonymous with factors or inputs.

Given a selection of different goods, designated as X_i ($i = 1, 2, \ldots, n$), available to a consumer for purchasing at prices P_i the problem facing the consumer can be stated as :

$$\max_{X_i} U(X_i) \qquad \text{subject to } \Sigma_i P_i X_i = M \qquad (1)$$

for $i = 1, 2, \ldots, n$; where $U(X_i)$ represents the consumer's utility function and M is the level of income available to him. In other words, equation (1) allows the consumer to choose among the commodity bundles that would give him the highest attainable level of utility while maintaining within the limits of his budget at the time of the purchase. The solution to equation (1) is usually carried out by the Lagrange method. That is,

$$\max_{X_i} L(X_i, \lambda) = U(X_i) - \lambda(P_i X_i - M) \qquad (2)$$

for $i = 1,2,\ldots,n$; where λ is the Lagrange multiplier interpreted as the marginal utility of income (money).[14] Differentiation of the Langrange equation (2) with respect to X_i and λ yields the first-order conditions of the constrained maximization

$$\partial U(X_i) \;/\; \partial X_i - \lambda P_i = 0 \quad \text{and} \qquad (3)$$

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[14] For the economic interpretation of the Lagrange multiplier, see L. Phlips, *Applied Consumption Analysis* (Oxford : North-Holland Publishing Company, 1974), pp. 21-22.

$$P_iX_i - M = 0 \qquad (4)$$

for i = 1,2,...,n. The demand functions can be obtained by solving equations (3) and (4) in terms of commodity prices and income (usually assumed to be exogenously determined). By utilizing the implicit function theorem,[75] the demand functions for consumer goods will have the form:

$$X_i = X_i(P_i,M) \quad \text{and} \qquad (5)$$

$$\lambda = \lambda(P_i,M) \qquad (6)$$

for i = 1,2,...n.

Equation (5) thus gives the condition that the quantity demanded of a given good is a function of its 'own' price, the prices of other goods and income. It is evident in equation (5) that the main concern of consumer demand theory is to determine the extent of substitution or complementarity between any two of the commodities being considered, with income held constant, or the income-induced change in demand when the relative prices remain unchanged. As well, it is clear that the condition underlying equation (5) (and hence equations (3) and (4)) does not provide sufficient framework in order to test whether the other factors cited in the first section of this chapter affect the level of demand for forest products. Andersson et al (1985) have also shown that the conditions implied in the second-order conditions of a constrained maximum and the equality of the sum of price- and income elasticities "do not generate enough structure for statistical testing and estimation purposes."[14]

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[75] See T.M. Apostol, *Mathematical Analysis* (Massachusetts : Addison-Wesley, 1957), p. 146.

Another problem inherent in consumer demand theory concerns the conventional theoretical assumption that the demand function can be formulated in such a way that it corresponds to the demand function either of an individual consumer or a group of consumers for a given period of time. This is done by taking the horizontal summation of all individual demand functions. However, in reality, consumers are heterogeneous and exhibit different marginal utilities so that an aggregation of individual demand functions may generate estimates of demand parameters that are unreliable as measures of all consumers' sensitivity to changes in prices and income. Also, it is reasonable to expect a non-linear aggregate demand function as a result of aggregation even if each individual demand function is linear, in which case the parameter estimates obtained from the former function would have little significance.

Andersson et al argue that:

> (1) As a general theory of demand in which u(x) is the preference function of any decision maker (manager of a firm, government or household purchases), it is too general to generate statistical hypotheses.
>
> (2) As a general theory of the consumer it uses too little of the structural information on individual consumers' behavior as developed by the behavioral

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[14] A.E. Andersson, et al., op. cit., p. 125.

sciences.

(3) If seen as a special theory of consumer demand, it would cover a very limited share (10-20%) of the total forest sector demand.''

Thus as far as forest products are concerned, the theory of consumer demand is not appropriate.

C. The Theory of Derived Demand, Cost and Demand Functions

In the theory of derived demand, the focus of analysis centers on the firm. The firm is seen to employ some intermediate inputs along with the primary factors so as to produce its output. The basic postulate is that the firm derives its factor inputs demand from the demand for the product it produces. Thus a rise in the demand for its output will likewise increase the firm's demand for factor inputs. However, the behavior of the firm dictates the optimum level of input mix, ceteris paribus, such that it will choose that set of inputs subject to whether it is a profit maximizer or cost minimizer. In actual empirical work, this problem facing the firm can be easily handled using the property of duality. If the firm is a cost minimizer which operates under perfectly competitive markets in both output and factor inputs, then its derived demand for all inputs can be uniquely determined subject to the level of output, input prices, and technology. The treatment of output and factor prices as exogenously determined seems

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''Ibid, p. 126.

most appropriate for the present study since the principal user[18] of imported hardwood logs and plywood is the construction industry which, in most cases, operates under contracts. These contracts stipulate the quantity of buildings or residential units to be constructed, among other conditions. With regards to import price, it is normally assumed to be exogenous to the importing country,[19] or more accurately to the end use industry. The assumption concerning the firm or an industry as a cost minimizer will therefore be maintained.

Technology is another factor important in the determination of the firm's derived demand for factor inputs. It provides information about the degree of substitutability or complementarity among inputs as well as the influence of technical change on the derived demand for particular inputs. In order to understand the effects, if any, of the various aspects of the technology on inputs demand, it is necessary to analyze the structure underlying the production technology of the demanding firm. This production technology can be specified, using duality theory, either by a production or cost function so long as the cost function satisfies certain regularity conditions. Given the relative advantage of the cost function compared to the production function in the estimation of production parameters,[10] it is preferable to use the former function along with Shephard's lemma to generate the derived demand functions and to test for technical change, scale effects and substitution possibilities.

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[18] The term "principal user" is defined in Chapter 4.

[19] See, for example, M.S. Khan, "Import and Export Demand in Developing Countries," *IMF Staff Papers*, XXI (1974): 678-693; and M. Goldstein and M.S. Khan, "Large Versus Small Price Changes and the Demand for Imports," *IMF Staff Papers*, XXIII (1976): 200-225.

A fundamental concern in the use of cost function relates to the choice of appropriate functional form that approximates the unspecified true production structure. It may be worth noting that prior to the introduction of the transcendental logarithmic (translog) cost function by Rockel and Buongiorno, and the Diewert cost functions by Doran and Williams in this area in 1982, most econometric demand models for forest products were based either on a cost or production function of Cobb-Douglas form. Although in most cases the Cobb-Douglas function was not explicitly stated, it was nevertheless implicit in the way the demand functions were expressed and calculated. The normal expression of demand function relates the quantity demanded of a particular forest product to its price, the prices of other wood and construction materials, the level of output, and sometimes, labor wages. While a number of demand functions would be specified, the calculation was usually done independently (i.e., single equation estimation). Estimation of single demand equations can reasonably be done only if the factor inputs employed in a production process are completely independent of each other. This is also referred to as global separability among inputs in that the use of each input is entirely independent of the other inputs. Thus one can calculate the demand for a given input without considering the quantity demanded of the other inputs. The Cobb-Douglas function however, has some limitations. Foremost among them is the restriction it imposes on the elasticities of substitution between inputs to be always equal to one, which is indeed a very rigid assumption unless supported by statistical test. Another consequence of using the Cobb-Douglas function when dealing with a system of demand equations is that the inputs, as revealed by the estimates of cross-price elasticities, are usually constrained to be always substitutes for each other.[6] In other words, it does not allow for complementarity among inputs to exist. Moreover, a Cobb-Douglas function does not permit the testing of possible alternative production technologies that may be of better approximations of the unspecified true production technology. With these limitations, a Cobb-Douglas function is certainly not the desirable functional form. There is another functional form used commonly in other fields but seldom in this area which is the Constant Elasticities of Substitution (CES). However, it is also undesirable since it is known to restrict the elasticities of substitution between inputs to be always the same (constant).

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[10] See H.P. Binswanger, "A Cost Function Approach to the Measurement of Elasticities of Factor Demand and Elasticities of Substitution," *American Journal of Agricultural Economics*, 56(1974): 377-386.

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[6] This was clearly illustrated from the results obtained by Rockel and Buongiorno (1982), see particularly Table 6 on page 216.

In as much as the true underlying production structure is infrequently known, Banskota suggests that

> ... selection of functional forms that are less restrictive appears to be more desirable. In other words, functional forms that do not a priori restrict the parameter estimates and other comparative static summary measures and that allow different hypotheses to be tested, are more desirable.[82]

This suggestion calls for a functional form that is flexible. A flexible function is one that allows us to test for specific characteristics of production technology, such as homotheticity, returns to scale and the like. Today, there exist a number of flexible form functions. These are the generalized Cobb-Douglas, generalized Leontief, generalized quadratic mean of order ρ, and translog functions. All these functions permit the arbitrary estimation of the elasticities of substitution and complementarity between factor inputs, as well as the determination of the specific features of the production structure (statistically) through the method of sequential hypotheses testing of different models that are nested within the most generalized function.[83] This latter characteristic helps determine the approximating function to the unspecified true function before the derived demand equations, including the demand elasticities, are estimated so as to avoid unreliable parameter estimates. In the following subsections the conditions underlying a well behaved cost function based from the neoclassical theory of production will be outlined and then the derivation of the derived demand functions will be explained. Likewise a translog cost function for multiple inputs-single output case will be introduced, as well as the cost-minimizing input cost share equations. Further discussion of the translog cost function and share equations in the context of hardwood plywood imports in the United States will be presented in the next chapter.

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[82] K. Banskota, An Economic Analysis of the Production Structure of the Sawmilling Industry in Alberta. Unpublished Ph.D. Dissertation. University of Alberta, Department of Rural Economy, Edmonton, 1984, p. 15.

[83] Ibid, p.16.

A General Cost Function

The problem of finding estimable derived demand functions is usually solved on the basis of the technology that is represented by the production function. Recently, the developments in duality permit the firms' or an industry's production technology to be adequately represented either by a production function or its dual, cost function. In other words, the relationships between the demand for inputs and the factors which influence it can be analyzed by either one of the two functions. An interesting feature of this 'dual' approach is that the quantities of the variable factors can be replaced by their prices or vice versa. In empirical work, it is convinient to use prices rather than quantities because the latter are difficult to determine and normally not readily available. Also the assumption that input prices are exogenous is a tenable one, especially if an imported intermediate product enters as an argument in the production (or cost) function.

Using a cost function, a single output n-inputs cost function can be written as

$$C = C(P_i, Y) \tag{7}$$

for $i = 1,2,\ldots,n$; where P_i represents input prices (assumed to be predetermined). The implication of condition (7) is that the cost is a function of input prices and output. This cost function (7) corresponds to a well behaved production function if it satisfies certain regularity conditions. Fuss, McFadden and Mundlak give these conditions as follows:[84]

(i) Domain. The cost function is a positive real-valued function for all positive prices and output, so that

$$C(P_i, Y) > 0 \tag{8}$$

for all $P_i, Y > 0, i = 1,2,\ldots,n$.

(ii) Monotonocity. The cost function is a non-decreasing function in input prices and output. This implies that a rise either in input prices or output cannot decrease cost. Thus if Y approaches infinity, $C(P_i, Y)$ also tends to infinity. Similarly, if P_i and P_j represent sets of two input prices such that $P_i \geq P_j$ and output constant, then

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[84] M. Fuss, D. McFadden and Y. Mundlak, "A Survey of Functional Forms in the Economic Analysis of Production," in M. Fuss and D. McFadden (eds), *Production Economics:A Dual Approach to Theory and Applications*, Vol. 1 (Amsterdam:North-Holland Publishing Company, 1978), pp. 219-268. Also, Banskota (1984) discussed these conditions in his dissertation

$$C(P_i, Y) \geq C(P_j, Y). \quad (9)$$

(iii) Continuity. The cost function is continuous in input prices.

(iv) Differentiability. The cost function is continuously twice differentiable in input prices and implies

(a) $\partial C / \partial P_i > 0,$ (10)

(b) $\partial^2 C / \partial P_i \partial P_j < 0.$ (11)

(a) and (b) are two important conditions in the quantification of derived demand for inputs. Property (a) allows us to generate the system of derived demand functions, that is

(a') $\partial C / \partial P_i = X_i$ (Shephard's lemma) (12)

where X_i is the derived demand for input i. Simultaneous estimation of derived demand functions (i.e., as a system of n equations) implies an important aspect of the behavior of the firm. The firm is said to decide simultaneously on the optimal input mix in order to minimize cost or maximize profit rather than independently for each input. The importance of property (b) is apparent in the actual estimation work since it can be re-expressed in such a way that the symmetry condition is obtained. This also implies concavity in input prices. This condition (symmetry) reduces the numbers of parameters to be estimated and hence conserves degrees of freedom. In addition, it reduces multicollinearity problems. Property (b) can thus be rewritten as

$$(b') \quad \partial^2C / \partial P_i \partial P_j = \partial^2C / \partial P_j \partial P_i \quad \text{or}$$

$$\partial X_i / \partial P_j = \partial X_j / \partial P_i \quad \text{(Symmetry)} \qquad (13)$$

where X_i and X_j are sets of two inputs.

(v) Homogeneity. The cost function is linear homogenous in input prices. This implies that the cost and input prices move in equal proportion, so that a twofold increase in input prices doubles the cost. Following Banskota (1984), this condition provides that

$$C(\alpha P_i, Y) = \alpha C(P_i, Y) \qquad (14)$$

where α is a positive scalar.

(vi) Concavity. The cost function is a concave function in input prices. This implies that for all P_i's and for every scalar α lying between 0 and 1, the following condition holds

$$\alpha C(P_i, Y) + (1-\alpha)\, C(P_i, Y) \leq C[\alpha P_i + (1-\alpha)P_i, Y] \qquad (15)$$

Nonviolation of any of the above conditions ensure the cost function to be a well behaved and minimum cost function derivable from some feasible production function.[85] Consequently, the cost minimizing bundle of inputs can be obtained from the cost function by applying Shephard's lemma, as illustrated by equation (12). From equation (12), the demand elasticities can be estimated, although these elasticities can also be calculated from the parameter estimates in the cost share equations as presented in the next subsections. However, implicit in the various conditions discussed above is the need to impose a priori certain restrictions on the cost function before the actual estimation in order to conform with the nature of the technology or rules of rational behavior. These restrictions include the linear homogeneity in input prices, symmetry, adding-up condition, Cournot's aggregation condition, and Engel's condition, which are discussed by Banskota (1984). The symmetry condition is, however, given by equation (13).[86] They are commonly regarded as maintained hypotheses (i.e., hypotheses which are not tested as part of the analysis). On the other hand, there are also some maintained hypotheses established so as to facilitate the analysis, such as separability between any pair of intermediate inputs or between primary factors and intermediate inputs.[87]

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[85] See Doran and Williams, op. cit., pp. 133-134.

In order to avoid the consequence of implausible maintained hypotheses in the actual estimation work it is thus safe to choose a functional form that is general and flexible, which embodies few maintained hypotheses, and allows the testing of specific characteristics of the technology. Given the four classses of flexible form functions, stated above, the translog cost function, developed by Christensen, Jorgenson and Lau[88] will be used as one of the models in the estimation of derived demand for hardwood plywood imports in the United States. The other demand models, which will also be fitted each for South Korea and Japan, will be presented formally in Chapter 4. The next subsection will introduce the translog cost function in a more general manner. This type of cost function has been used by Rockel and Buongiorno (1982) in the determination of derived demand for wood and other inputs in the United States residential construction. Their study did not take into account imported intermediate inputs, which the present study considers.[89]

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[86] Below, the specific restrictions imposed by symmetry condition on the cost function is illustrated in the context of the translog cost function.

[87] For the different definitions of separability, see C. Blackorby, D. Primont and R.R. Russell, *Duality, Separability and Functional Structure : Theory and Economic Applications* (New York : Elsevier North-Holland, Inc., 1978), pp. 41-53.

The Approximate Translog Cost Functions

The use of the translog cost function embraces the usual assumption that it best approximates up to the second order any arbitrary cost function. If this holds for the cost function underlying the residential construction industry in the United States, then the translog cost function can be utilized to test for the various feasible alternatives of the production technologies that nearly approximate the true technology in the industry. In order to examine a large set of alternatives, the translog cost function should be expressed in its most general form. This can be done by postulating that the industry's cost function can be adequately approximated up to the second order by a nonhomothetic translog cost function.[10] Imposition of the necessary restrictions in the nonhomothetic translog cost function yields a particular characteristic of the residential construction industry's technology. Such restrictions will be provided below. In the literature, the relevant production characteristics frequently examined are homotheticity, homogeneity, returns to scale, technical change and substitution possibilities. To account for technical change, it is necessary to introduce in the nonhomothetic translog cost function a variable that can capture such change. The conventional procedure is to include a time variable. With this consideration, the nonhomothetic translog cost function can be written as:[11]

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[88] L.R. Christensen, D.W. Jorgenson, and L.J. Lau, "Transcendental Logarithmic Production Frontiers," *Review of Economics and Statistics*, 55(1973) : 28-45.

[89] A review of their study can be found in section E below.

$$\begin{aligned} \ln C = {} & \gamma_0 + \Sigma_i \gamma_i \ln P_i + (1/2)\, \Sigma_i \Sigma_j \gamma_{ij} \ln P_i \ln P_j \\ & + \gamma_y \ln Y + (1/2)\, \gamma_{yy} (\ln Y)^2 + \Sigma_i \gamma_{iy} \ln P_i \ln Y \\ & + \gamma_t t + (1/2)\, \gamma_{tt}\, (t)^2 + \gamma_{yt} \ln Y t \\ & + \Sigma_i \gamma_{it} \ln P_i t, \end{aligned} \qquad (16)$$

for $i,j = 1,2,\ldots,n$; $i \neq j$. The P_i represents the price of factor i ($i = 1,2,\ldots,n$), Y is a measure of the level of output and t stands for time which reflects technical change. The γ's are the parameters of the approximating translog cost function, which will be estimated. This particular cost function (16) is considered to satisfy the regularity conditions given above.

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[10] This has been the usual assumption in most empirical studies that used translog cost function. See, for example, E.R. Berndt and D.O. Wood, "Technology, Prices, and the Derived Demand for Energy," *Review of Economics and Statistics*, 58(1975) : 259-268. See also Binswanger (1974), Banskota (1984) and Rockel and Buogiorno (1982).

[11] The current time subscript representing specific period of observation is omitted for clarity and convenience, but should be borne in mind.

The minimum-cost input share equations can be generated by differentiating the translog cost function (16) with respect to the logarithms of the ith input prices, that is

$$S_i = \gamma_i + \Sigma_j \gamma_{ij} \ln P_j + \gamma_{iy} \ln Y + \gamma_{it} t \qquad (17)$$

for $i = 1,2,...,n$; where $S_i = P_iX_i / \Sigma_j P_jX_j$ and X_i, as given in equation (12),is the quantity demanded of input i. The cost share equations indicate the proportion of total cost attributed to a particular input. In other words, they give indications of the relative importance of a factor input in the production of the industry's output, as judged from its share in the total cost. Thus the larger the share of a given input in production of the final output, the more dependent will the technology be on that input. Also, it becomes difficult to substitute other factor inputs for the particular input being considered. Obviously, the price of that input will determine the price of the final output. Furthermore, the cost share equations have other interesting applications. It can be shown that equation (17) can provide parameter estimates and test hypotheses on demand elasticities, substitution possibilities, technical change, and scale economies. Basically, the parameters of the nonhomothetic translog cost function can be derived from the cost share equations except for the parameters of quadratic output and time variables. In most recent studies, the cost share equations are estimated jointly with the cost function rather than calculating independently the cost share equations in view of the potential improvement in the efficiency of the parameter estimates.[12]

In the derivation of the cost share equations from the cost function, it is implicitly assumed that in each observation period the adjustment of the input mix to input price change is full and complete.[13] The same assumption holds for the derived demand elasticities of inputs, if the elasticities are calculated following the conventional procedure (i.e., $\eta_{ij} = \sigma_{ij} S_i$ [14]). This means that the adjustment in demand for an input to, say, a change in its price or other factor prices is instantaneous within the sample period considered. This assumption can be reasonably accepted so long as the study uses annual data in which the adjustment lags are presumed to be completed within one year. But this is obviously an undesirable assumption if shorter time periods are being considered, especially for policy formulation and forecasting purposes. In the absence of an appropriate estimation technique which allows the introduction of lagged adjustment mechanism in the full dual system (i.e., the cost function and (n - 1) share equations) however, many researchers undertook studies with this implied assumption.

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[12] For an elaboration of this matter, see L.R. Christensen, and W.H. Green, "Economies of Scale in US Electric Power Generation," *Journal of Political Economy*, 84(1976) : 655-676.

[13] J. Johnston, *Econometric Methods* (New York : McGraw-Hill Book Company, 1984), p. 337.

[14] The next subsection shows the derivation of the factor demand elasticities.

The cost share equations cannot be estimated altogether since, as it is apparent in equation (17), the value share of all inputs must add to one. This means that one equation has to be dropped to permit estimation of the remaining parameters and in order not to result in overidentification. The value of the omitted share equation can be computed using the 'adding-up' condition. The 'adding-up' condition implies that the following restrictions must hold for the parameters of the translog cost function :

(i) $\Sigma_i \gamma_i = 1$

(ii) $\Sigma_i \Sigma_j \gamma_{ij} = 0$

(iii) $\Sigma_i \gamma_{iy} = 0$ (18)

(iv) $\Sigma_i \gamma_{it} = 0$

(v) $\Sigma_i \gamma_{ij} = \Sigma_j \gamma_{ji} = 0$

for i,j = 1,2,...,n; $i \neq j$. The condition that requires these restrictions is also referred to as linear homogeneity in input prices. Denny and Fuss [95] note that in order for the translog cost function to be considered as a quadratic approximation of an arbitrary cost function, the additional constraints required are

$$\gamma_{ij} = \gamma_{ji} \tag{19}$$

for all i and j, $i \neq j$. These restrictions (19) are known as the Slutsky symmetry condition. In most empirical works the constraints defined in equations (18) and (19) are the usual maintained hypotheses adopted when using flexible functional forms.

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[95] M. Denny and M. Fuss, "The Use of Approximation Analysis to Test for Separability and the Existence of Consistent Aggregates," *American Economic Review*, 67 (1977) : 404-418.

As stated earlier, the nonhomothetic translog cost function is a general form of this particular cost function and therefore would be an appropriate starting point for sequential hypotheses testing of different models (i.e., different production characteristics). The primary purpose of hypotheses testing has already been given above, but to restate it : to choose the particular cost function that closely approximates the true production structure in residential construction industry in the United States. The procedure for hypotheses testing will be described in the next chapter. In the meantime it seems necessary to examine some of the relevant structural characteristics of technology.

Some Relevant Production Characteristics in the Residential Construction Industry

This subsection will provide a brief description and implications of the following aspects of production technology: homotheticity, homogeneity, returns to scale, technical change and substitution possibilities between inputs. Each of these characteristics imposes certain restrictions on the general, nonhomothetic translog cost function (16). The significance of each characteristic can be tested by comparing the nonhomothetic translog cost function model to one with the necessary restrictions in a restricted-unrestricted framework. In this case, either a likelihood ratio test or an F test is a feasible statistical test. The ultimate aim of this statistical test is to arrive at the final form of the translog model that more closely represents the production technology in the residential construction industry. This final form of the model provides the appropriate variables to be included in the quantification of the derived demand for factor inputs. More importantly, the accuracy of the demand elasticity estimates depends to a large extent on the reliability of the final model.

1. Homotheticity, homogeneity and returns to scale. These three characteristics of production are related in one aspect; namely, each one provides a relationship between the level of output and the use of factor inputs. Homotheticity is described by "the presence of expansion paths with scale which are rays through the origin."[16] This means that if the cost function is homothetic, an increase in the level of output will not change the ratio of factor inputs, given the factor price ratios. In contrast, a nonhomothetic cost function will display changes in factor proportions with an increasing output levels even though the ratio of factor prices remain unchanged. Shephard[17] has shown that if the production function technology is characterized by homotheticity, the approximating cost function is

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[16] See McFadden, Fuss and Mundlak, op. cit., p. 222.

[17] R.W. Shephard, *Theory of Cost and Production Functions*, (Princeton:Princeton University Press, 1970).

multiplicatively separable in input prices and output. This implies that the cost function, such as the one given in equation (7), can be written as :

$$C = c(P_i) \bullet d(Y) \tag{20}$$

for i = 1,2,...,n. There are two important economic properties implicit in a homothetic cost function (20). Firstly, the changes in the level of output do not in any manner affect the ratio of any two derived demand equations and secondly, the elasticity of cost with respect to output is independent of input prices. In the translog cost function case, homotheticity requires that the quadratic input price-output interaction terms be equal to zero; that is, all $\gamma_{iy} = 0$.

Homogeneity is a special case of homotheticity. A homogenous function describes isoquants along any ray that are parallel. Stated differently, the marginal rate of substitution between inputs depends only on the input proportions and hence is independent of the level of output. Also, it suggests that the elasticity of cost with respect to output is constant in the context of a homogenous cost function. In examining whether the translog cost function exhibits homogeneity, the parameter referring to the quadratic output term must be set to zero, i.e., $\gamma_{yy} = 0$, in addition to homotheticity.

Returns to scale is related to homogeneity. For example, any function that is homogenous of degree 1 is also called constant returns to scale function. Thus a constant returns to scale function is said ~~to~~ be one of the many classes of homogenous functions, which has the property that increasing all inputs by a multiple ϕ increases output by a multiple ϕ^x, where x is the degree of homogeneity.[98] In simple terms, a constant returns to scale function implies that the level of output will change equally proportional to the level of inputs (i.e.,doubling all inputs doubles output). Constant returns to scale in the translog cost function indicates in addition to homogeneity the restriction that $\gamma_y = 0$. Rejection of the null hypothesis that $\gamma_y = 0$ would mean that the cost function exhibits either increasing or decreasing returns to scale. Note that in this case the changes in returns to scale do not alter the ratio of factor inputs.

2. Technical change. This is a salient aspect in the analysis of production technology and estimation of derived demand for inputs. An industry can employ or modify a wide variety of techniques within known technology, or a totally new technology, in producing the final output, with each technique requiring the use of an appropriate mix of factor inputs. One consequence of technical change is evident in changing factor intensities over time in that some inputs are required at larger quantities relative to others. Or, as in the case of neutral technical change, factor proportions remain unchanged over time.

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[98] See P.R.G. Layard and A.A. Walters, *Microeconomic Theory* (New York : McGraw-Hill Book Company, 1978), pp. 64-66.

Technical change results in the shift of the isoquants towards the origin. This implies that, given the input prices, the original level of output can be maintained at a decreasing cost by specializing on particular inputs, such that the more available and less expensive inputs can be substituted for those becoming scarce and more expensive inputs. Technical change, of course, arises from a number of factors such as research and development, improvement in management and operation skills and the like. The effect of technical change on total cost can be examined by differentiating the cost function with respect to time , where time as already indicated serves as a proxy for technical change.

The present study assumes that the technical change is in accordance with the Hicksian concept of technical change.[''] This concept states that the technical change is Hicks neutral if the marginal rates of technical substitution (MRS) between two factor inputs does not change over time at increasing levels of output, given the factor price ratios. In the context of the translog cost function, Hicks neutral technical change means that the quadratic time-input price interaction terms are equal to zero, that is all $\gamma_{it} = 0$. If a Hicks nonneutral technical change occurs the factor proportions will change when output changes, even if the factor price ratios remain constant.

[''] For a detailed discussion on technical change and different definitions, see M.I. Nadiri, "Some Approaches to the Theory and Measurement of Total Factor Productivity," *Journal of Economic Literature*, 8(1970) : 1137-1177.

For example, technical change will be factor using in input i if the MRS of input i for j reflects an increase over time.

Following Binswanger,[100] the measurement of technical change can be carried out by utilizing the input cost share equations. Differentiation of each input cost share equation with respect to time ($\partial S_i / \partial t$) yields the parameter estimates for technical change. The technical change can be defined as follows :

$\partial S_i / \partial t = \gamma_{it} > 0$ means Hicks factor i-using

$\partial S_i / \partial t = \gamma_{it} = 0$ means Hicks factor i-neutral (21)

$\partial S_i / \partial t = \gamma_{it} < 0$ means Hicks factor i-saving

where S_i is the cost share of factor i, when factor prices are held constant.

3. Elasticities of Substitution and Factor Demand Elasticities. The elasticities of substitution measure the change in factor proportions arising from the change in relative factor prices at a constant output level. If i and j are two sets of inputs that can be substituted for each other, then an increase in the price of input i will increase the demand for input j and and a decrease in input i demand, assuming factor prices except for i and j and output are constant. However, if inputs i and j act as complements for each other, an increase in the price of either input will result in a decrease in the demand for both inputs, ceteris paribus.[101]

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[100] See Binswanger, op. cit., p. 397.

[101] For reference on the various concepts and definitions of

The elasticities of substitution can be calculated by utilizing the parameter estimates in the cost share equations, with the following formulas :[102]

$$\sigma_{ij} = 1 + (\gamma_{ij} / S_i S_j)$$

and (22)

$$\sigma_{ii} = (\gamma_{ii} + S_i^2 - S_i) / S_i^2$$

for i = 1,2,...,n; $i \neq j$, where σ_{ij} is the elasticity of substitution between inputs i and j, and S_i is as defined in equation (17). The inputs i and j are considered substitutes when $\sigma_{ij} > 0$ and complements when $\sigma_{ij} < 0$. A considerable advantage can be attained when using the translog cost function (and cost share equations) to estimate the partial elasticities of substitution (PES) since the elasticity estimates are not constrained to particular values. Moreover, the Cobb-Douglas function can be easily derived from a translog cost function by setting the second order price terms on the latter cost function equal to zero (i.e., $\gamma_{ij} = 0$, $i \neq j$). In this case, the inputs are treated as globally separable.

The factor demand elasticities measure the change in the quantity demanded of a given input to a change in its price, when other factor prices and output are held

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[101](cont'd) elasticities of substitution, see Y. Mundlak, "Elasticities of Substitution and the Theory of Derived Demand," *Review of Economic Studies*, 35 (1968): 225-236.

[102] See W. Adamowicz, Production Technology in Canadian Agriculture : Effects of Aggregation on Estimation and Structure. Paper presented at the Canadian Agricultural Economics and Farm Management Society, Agricultural Institute of Canada Agricultural Meetings, Charlottetown, P.E.I., June 23-27, 1985.

constant. These elasticities can be estimated using the formulas as follows :

$$\eta_{ii} = \sigma_{ii} S_i$$

and (22)

$$\eta_{ij} = \sigma_{ij} S_j$$

Here η_{ii} is the own price factor elasticity (or derived demand elasticity for input i) and η_{ij} is the cross price factor demand elasticity. The η_{ij} has a similar interpretation to the σ_{ij}. A given input is said to be price elastic if $|\eta_{ii}| > 1$ and price inelastic if $|\eta_{ii}| < 1$. In general $\eta_{ij} \neq \eta_{ji}$ even though the PES between factor i and j are symmetrical ($\sigma_{ij} = \sigma_{ji}$).

It must be noted that these demand elasticities are based on the assumption that factor demand adjusts instantaneously to the new equilibrum value whenever the variables that influence demand change. Thus adjustment is always completed within the time period considered. Yet in reality the end use industry may not be able to react promptly to any stimulus, such as a change in the price of a particular input it uses, along with other inputs in the production of the final output, because of such factors as adjustment costs, institutional constraints, uncertainty, etc. Instead, it may delay its response over several periods while undertaking the necessary measures. For a study involving the estimation of derived demand for imported intermediate inputs such adjustment lags should be considered. This is the main issue to be dealt with in more detail below.

D. Lags in Import Demand for Intermediate Inputs

In studying import demand for intermediate inputs, such as hardwood logs and plywood, it is highly important to recognize all the possible "constraints" [103] which may cause rigidity in the behavior of the end use industry. This is in view of the fact that economic and related variables which affect demand do not remain constant over a period of time but vary quite radically (at least for some variables) from time to time. Thus the end use industry and hence the importers may not be able to adjust immediately their level of imports to fully account for a change in any relevant variables because of some "constraints", so that within each period the adjustment (in imports) toward the optimum or desired level is only partial. Accurate estimates of the pattern of lag structure, length of the lag and the coefficients of adjustment or expectation are certainly vital information for policy makers and forest products producers in forecasting the demand for their products in the foreign markets. It seems however that little attention is given to determine these three major parameters. The pattern of lag structure provides information regarding the manner in which the lags are distributed over time as a result of the change in the explanatory variable. For example, an autoregressive model (i.e., adaptive expectation model) assumes that the impact of the explanatory variables on the import demand declines in geometric progression. This simply implies that the lagged values of the explanatory variables closer to the beginning of the adjustment period have a greater impact on demand as compared to those lagged values far from that particular period. In contrast, a distributed lag model (i.e., Almon's polynomial lag model) will consider such impact to lie on a finite polynomial of a selected order. In this case different alternative patterns of lag structure can be examined. The estimation of the lag lengths is one of the basic goals in the use of dynamic models,[104] and also of greater relevance for forecasting short- and long-term trends in demand. A specific lag length indicates the time period involved in which the full impact of the lagged values of a given variable is highly significant in a statistical sense. The coefficient of adjustment or expectation, on the other hand, in the context of import demand implies the rate of adjustment of the actual level of imports toward the desired (or long run) level.

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[103] The term "constraints" here differs in meaning from the constraints referred to in the previous sections where some parameters are restricted to some particular values. Below these "constraints" are described properly.

In order to determine the three major parameters so far discussed there is a need for a model that is relatively flexible in the sense that it allows the examination of the different alternative patterns of lag structure, the lengths of the lag, etc. In this section, some of the dynamic models often used in forest products demand studies will be reviewed with emphasis on their advantages and limitations. Implicit in the application of dynamic models is the notion that the firm or an industry makes decisions in terms of the short and long runs, such that in the short run it is unable to adjust its demand for inputs because of some "constraints," which will be discussed below.

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[104] Dynamic models are sometimes referred to as distributed lag or autoregressive models and usually contain independent variables that are observed at different points in time.

There are at least three main reasons or "constraints" that contribute to the occurrence of lags in demand formation. These are institutional, technological, and psychological constraints. The institutional constraints can emanate from the different formalities involved in forest products trade, such as those discussed in Chapter 2, or from a prior commitment on the part of the end use industry which requires the completion of the agreed conditions in specified period of time. This latter case is evident in the construction industry in which the quantity and specifications of the buildings or residential units to be constructed are stipulated in the contract entered into force by and between the industry and the other party. In terms of import demand, Khan and Goldstein[103] note, and as observed earlier by Malinvaud,[104] that "many imports are linked to contracts extending over a period of time and thus cannot respond promptly to changes in demand." This simply indicates that the level of imports in the short run can be adjusted only partially to its desired level, at least while the contracts remain in force. Also, imperfect markets for the different inputs may restrain the industry to change its input mix whenever the price of one input increases faster relative to the others. Of course, a change in input mix means a change in the pattern of expenditures, which may result to higher cost associated with input procurement and adjustment in the production method. The imperfection of the markets and the costs of adjustment may convince the industry to maintain the present production technique using the original set of inputs, at least for some time while making the necessary adjustment.

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[103] See Khan (1974) and Goldstein and Khan (1976).
[104] E. Malinvaud, *Statistical Methods of Econometrics*, (Amsterdam:North-Holland Publishing Company, 1970).

The technological constraints can be due to adjustment costs and uncertainty. Van Bochove[107] cites three sources of adjustment costs. If the industry for instance desires to change its production method or technology that allow reduction in the use of a particular input that is becoming scarce, then it can do so only with some cost. The reasons for this are as follows. First, the capital and labor are not perfectly homogenous. Everytime a new technology is introduced into the entire production system, it requires the conversion or movement of some machines from one sector to another; and to some extent, even a new machine may be needed to be installed. If the unsuitable old machine cannot be fitted into the other sectors, then they will either be left idle or sold at very low prices. Similarly, the labor force requires training to enable them to work efficiently with the new machines and this necessarily requires time. Thus every activity related to adjustment in production technology involves large costs. Second, with the new technology and different input mix, the final product can be considered a new product and therefore there is a possibility that the initial output will be lower than it would be if it is the usual output being produced. The consequence of this adjustment process, although temporary, is that the unit cost per output will be high in the initial phase because of the high initial investment costs. Finally, there are large costs involved in the marketing and distribution of the new product. All these sources of adjustment costs are expected to influence demand for inputs, perhaps in different magnitude, but one can postulate in general that the larger the adjustment costs the slower will be the adjustment to the new equilibrum value when any of the independent variables changes.

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[107] C.A. Van Bochove, *Imports and Economic Growth* (The Hague:Martinus Nijhoff Publishers, 1982), pp. 58-59.

Uncertainty may also affect the industry's decisions on production technology and demand for inputs. If the industry is considering to introduce a new technology, but feels that it does not have enough knowledge of the associated adverse impacts, then it may decide to defer such plan until sufficient information becomes available. Consequently, it will remain using the existing technology and therefore price-induced changes in input demand will be constrained by the rate at which the technology is replaced. Measures to avoid the effects of uncertainty also constrain the industry to react promptly to changes in input prices. Take for example the contracts that govern the sale of forest products. These contracts may serve the purpose of ensuring input supply, at least for a specified period of time, just in case an unexpected problem arises in the supply side. Thus contracts are generally viewed to be of great value to many importers and exporters. As noted earlier, however, these contracts make it difficult for the industry to adjust its demand for inputs when their prices change.

The last source of lags in demand adjustment is due to psychological reasons. Decision makers may consider the changes in economic variables as only temporary and hence continue to purchase its inputs even at higher prices on the presumption that the costs of adjustment may more than offset the additional costs on inputs. The same may hold true if they become convinced that the price of the final output, where the inputs are used, will likewise increase at a comparable rate with that of the input prices. These speculations about the input and output prices combined with uncertainty and imperfect knowledge on substitution possibilities between inputs cause rigidity in behavior of the decision maker. Hence it is reasonable to suppose that the current level of demand for intermediate inputs depends in part on the current values of input prices or variables that shift the industry's demand curve and in part on their previous values. In the literature, such relationship is accounted for by introducing the appropriate lagged variables in the demand equation.

The introduction of lags into the import demand function can be achieved in two ways depending upon the assumption postulated about the behavior of the importer. This assumption must recognize the major factors which an importer considers in making decisions, such as the future demand for imports in the domestic market in which he operates and the various constraints enumerated above. Thus, in import demand for forest products for instance, it is not uncommon to find the residential construction industry's final output entering as a main argument in the importer's demand function, where the industry's demand for imports is essentially a derived demand. One way of specifying lags is to assume that the quantity of imports in the short run set by the importer is adjusted partially to its desired (long run) level. If this is so, a major addition in the static demand model would be a lagged dependent variable, which serves as a new explanatory variable in the demand function. Nerlove[108] has proposed a model which provides a mechanism that links the change in the (actual) quantity of imports (X) in period t to the difference between the desired demand for imports in period t, $X*_t$, and the actual level of imports in the previous period, t-1. This can be illustrated as follows. If the main demand determinants include the prices of inputs, P_i (i = 1,2,...,n), which includes the import price, and a measure of output Y, Nerlove postulates that the desired level of imports is a function of actual current prices and output, which in log linear form can be written as:

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[108] See M. Nerlove, "Estimates of the Elasticities of Supply of Selected Agricultural Commodities," *Journal of Farm Economics* , 38(1956): 496-509; and *Distributed Lags and Demand Analysis*, USDA Agriculture Handbook No. 141, Washington, 1958.

$$X*_t = a + b(\ln P_i)_t + c(\ln Y)_t + e_t \tag{24}$$

for t = 1,2,...,n; where e_t is a random error term which occurs in period t. This equation (24) is not feasible for estimation since the value of X* is unobservable. But it is possible to obtain observable value of $X*_t$ in terms of actual imports X_t by using the mechanism suggested by the partial adjustment model. The adjustment process takes the form :

$$\Delta\ln X_t = \beta[\ln X*_t - \ln X_{t-1}] \tag{25}$$

where $\Delta\ln X_t = \ln X_t - \ln X_{t-1}$ and β is the adjustment coefficient. The value of β should fall between zero and one. This equation (25) simply states that the actual change in the quantity of imports in period t, ($\Delta\ln X_t$), is only a fraction β of the desired adjustment, which is equivalent to the right hand side terms in (25) except β. The adjustment in imports to its desired level is said to be instantaneous when β = 1 and it would be very slow when β takes a value equal or close to zero.

The import demand function can be derived by substituting equation (24) in equation (25) to yield

$$\ln X_t = \beta a + \beta b(\ln P_i)_t + \beta c(\ln Y)_t + (1-\beta)\ln X_{t-1} + \beta e_t \qquad (26)$$

where βb and βc are respectively, the short-run price and output elasticities. Equation (26) is the final form of demand function for estimation. The long run elasticities can be calculated by dividing the short-run elasticities by one minus the elasticity coefficient of the lagged dependent variable. This model however has some drawbacks. First of all, the influence of prices and output is constrained only to their current values and therefore previous levels of prices and output are assumed to have zero impact on the current actual demand for imports. Secondly, the disturbance term may no longer be independent or stochastic since it appears to be correlated with the lagged dependent variable. Thus, estimation of equation (26) will result in unbiased but not efficient parameter estimates, especially if OLS is used. Finally, it assumes equal adjustment coefficients for input prices and output and the impacts of the explanatory variables to decline geometrically. Both of these indeed are rigid assumptions since, in the first place, it may well be that importers adjust to output changes faster than to price changes. The reason for this lies on the fact that importers remain in close contact with the end users of imports than with the sources of information concerning price changes, etc. Also, the factors which cause rigidity in behavior may not show a geometrically decaying pattern of adjustment but instead an adjustment pattern that builds up slowly.[109]

The other approach in introducing lags in import demand function, attributed to Cagan,[110] is based on the assumption that the importer makes short-term decisions according to his expected values of the variables affecting demand. More formally, it assumes that the demand for imports in period t, X_t, depends not on the actual values of (using the same explanatory variables as in the above model) P_i and Y in that period but on their expected values at t; i.e., $(P_i*)_t$ and $(Y*)_t$ respectively. In log-linear form, this relationship can be written as :

$$\ln X_t = a' + b' (\ln P_i*)_t + c' (\ln Y*)_t + e'_t \tag{27}$$

The basic notion underlying this approach is that if the importer expects input prices and output to be higher in the future, he would import more today and vice versa. Equation (27) can not be estimated in its present form since there is no way to observe the expected values of P_i and Y. However, as Cagan suggested, one can suppose that the expectations about the level of any explanatory variable (F*) in period t are modified in proportion of the error associated with the level of expectations made previously, such that

$$F*_t - F*_{t-1} = \theta(F_t - F*_{t-1})$$

or

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[109] For further discussions on the inherent limitations of this model, see E.E. Leamer and R.M. Stern, *Quantitative International Economics* (Boston:Allyn and Bacon, Inc., 1970), pp. 24-25.

[110] P. Cagan, "The Monetary Dynamics of Hyperinflation," in M. Friedman (ed.), *Studies in the Quantity Theory of Money*(Chicago:Chicago University Press, 1956).

$$F^*_t = \theta F_t + (1 - \theta)F^*_{t-1} \qquad (28)$$

where θ is the expectation coefficient and takes a value $0 \leq \theta \leq 1$. The implication of condition (28) is that the current expectations of the importer regarding the value of an explanatory variable are influenced partly by his current experience (θF_t) and partly by his previous expectations, $(1 - \theta)F^*_{t-1}$. The importer's expectations are said to remain unchanged when $\theta = 0$. If $\theta = 1$, expectations are always the same as current values. Like the partial adjustment model, this approach assumes a distributed lag that decays in a geometric fashion for the expected value of an explanatory variable. Similarly, this uses Koyck's transformation procedure so that the input prices and output are taken to exhibit the condition implied in condition (28), and with the proper substitutions equation (27) can be solved in terms of observable variables to yield the final form of the import demand equation:

$$\begin{aligned} \ln X_t = {} & \theta a' + \theta b'(\ln P_i)_t + \theta c'(\ln Y)_t \\ & + (1-\theta)\ln X_{t-1} + e'_t - (1-\theta)e'_{t-1} \qquad (29) \end{aligned}$$

Notice that equation (29) is basically the same as equation (26) except for the error term. This implies that the present model, commonly known as the adaptive expectation model, has the same properties and hence problems as the partial adjustment model. However, the former model has error terms which induce severe serial correlation compared to the latter model. These two models by the way are examples of autoregressive models, in which a lagged dependent variable appears as one of the explanatory variables. It should be noted that one statistical problem inherent in autoregressive models is the presence of a stochastic variable in the explanatory variables which should be attended to prior to actual estimation.

The assumption of both the adaptive expectation and partial adjustment models that the coefficients of adjustment or expectation, or in general the effects of changes in the explanatory variables on import demand, decline over time seems to be overly restrictive and unrealistic.[111] Almon[112] has proposed a model that is considered by some authors as flexible in the sense that "a great variety of shapes for the weights of lag distribution may be considered while preserving some parsimony in the number of independent parameters."[113] In addition, the adjustment coefficients can be estimated independently and therefore are not necessarily the same for all explanatory variables. The method of estimating the Almon model is similar to the method of least squares with linear restrictions which constrain the coefficients of the lagged exogenous variables to lie on a finite polynomial of a suitable order. This model is grounded on the same assumption as that of the adaptive expectation model with slight modification. To illustrate this, it is useful to rewrite equation (27):[114]

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[111] For an elaborate discussion on this argument, see Z. Griliches, "Distributed Lags : A Survey," in J.M. Dowling and F.R.Glahe, *Readings in Economic Theory*, (Colorado:Colorado University Press, 1970), pp. 109-142.

[112] S. Almon, "The Distributed Lag Between Capital Appropriations and Expenditures," *Econometrica*, 33(1965) : 178-196.

[113] M. Pagano and M. Hartley, "On Fitting Distributed Lag Models Subject to Polynomial Restrictions," *Journal of Econometrics* 16(1981) : 171-198.

$$\ln X_t = a + b(\ln P_i{*})_t + c(\ln Y{*})_t + e_t$$

Instead of using Cagan's "adaptive" rule, Chuo and Buongiorno[115] suggest to consider that the formation of expectation is according to more flexible distributed lag equations which are different for P_i and Y. Following Chou and Buongiorno, the resulting distributed lag import demand model is

$$\ln X_t = a + \sum_{k=0}^{K} b_k (\ln P_i)_{t-k} + \sum_{k=0}^{K} c_k (\ln Y)_{t-k} + e_t \qquad (30)$$

for $t=1,2,\ldots,n$; where X_t is the quantity demanded of imports in period t, $(.)_{t-k}$ denotes the kth lag on the independent variables P_i and Y ($k = 0,1,\ldots,K$) and e_t is a random error term. The b_k's and c_k's are constant parameters which are assumed to lie on a polynomial m of the rth degree. If the parameter can be approximated by a quadratic polynomial, then approximately

$$b_k = \alpha_0 + \alpha_1 m + \alpha_2 m^2$$

$$c_k = \delta_0 + \delta_1 m + \delta_2 m^2 \qquad (31)$$

In other words if some function f(m) which follows a polynomial in m of the second degree can approximate b_k and c_k, then f(m) can be utilized to estimate such parameters, given the values of α's and δ's. This can be done by substituting equation (31) in equation (30) to yield

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[114] Notice that the apostrophe after the parameters are omitted for convenience.
[115] See J. Chou and J. Buongiorno, op. cit., p.233.

$$\begin{aligned} \ln X_t &= a + \sum_{k=0}^{K} [(\alpha_0 + \alpha_1 m + \alpha_2 m^2)\ln P_{i\,t-k} \\ &\quad + (\delta_0 + \delta_1 m + \delta_2 m^2)\ln Y_{t-k} + e_t \\ &= a + \alpha_0 W_{0t} + \alpha_1 W_{1t} + \alpha_2 W_{2t} + \delta_0 W_{3t} \\ &\quad + \delta_1 W_{4t} + \delta_2 W_{5t} + e_t \qquad (32) \end{aligned}$$

where $W_{0t} = \Sigma_{k=0} (\ln P_i)_{t-k}$, $W_{1t} = \Sigma_{k=0}\, m(\ln P_i)_{t-k}$, $W_{2t} = \Sigma_{k=0}\, m^2(\ln P_i)_{t-k}$, $W_{3t} = \Sigma_{k=0} (\ln Y)_{t-k}$, $W_{4t} = \Sigma_{k=0}\, m(\ln Y)_{t-k}$, $W_{5t} = \Sigma_{k=0}\, m^2(\ln Y)_{t-k}$,

The W's are linear combinations of the lagged independent variables.[114] Using OLS to estimate equation (32) will provide the estimates of α's and δ's, which in turn can be substituted in equation (31) to obtain the values of the b_k's and c_k's. Each b_k or c_k gives a measure of the change in imports in period t as a result of a change in input price or output in period t - k. The long-run elasticities of import demand with respect to input prices and output are obtained by taking the summation of b_k's and c_k's, i.e., Σb_k, Σc_k.

Under the Almon scheme one can test the appropriate shapes for the lag distribution and lag lengths rather than impose them a priori, as in the case of the previous models. However, the main concern in the use of this model lies on the selection of the appropriate length of the lag and degrees of the approximating polynomial. In spite of the number of the available approaches there is not yet a concensus as to which one is most preferable. Some authors propose a search-type approach in which various lag lengths and degrees of polynomial are searched on the basis of some statistical criteria. Keleijan and Oates [117] suggest to choose that particular value of lag length and degree of the polynomial that maximizes the R^2 statistic. In contrast, Schmidt and Waud [118] recommend the one that minimizes the standard errors of the residuals. The problem with this type of approach is that it requires a lot of experimentation which is computationally cumbersome and may not be worth the cost of pursuing it. Other authors focus on the determination of the value of the degree of the polynomial, with a given assumption about the maximum lag length. Johnston[119] suggests a sequential procedure for finding a suitable degree by initially setting a polynomial of reasonably high degree, and test the null hypothesis that the degree of the approximating polynomial is less than or equal to r, given the condition that its maximum value is K.[120] This hypothesis can be tested using the F test or likelihood ratio test. The assumption that the optimal values of K is known is however not at all times judicious.

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[114] For the formal derivation of the W's, see A. Koutsoyiannis, *Theory of Econometrics*, (London: Macmillan Publishers Ltd., 1977), pp. 299-304.

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[117] H.H. Keleijan and W.E. Oates, *Introduction to Econometrics : Principles and Applications*, (New York:Harper and Row, 1974).

[118] P. Schmidt and R.W. Waud, "The Almon Lag Technique and the Monetary Versus Fiscal Policy Debate," *Journal of the American Statistical Association*, 68(1973):11-19.

[119] J. Johnston, op. cit., pp. 352-357.

[120] The same procedure was used in the study by L.G.Godfrey and D.S. Poskitt, "Testing the Restrictions of the Almon Lag Technique," *Journal of the American Statistical Association*, 70(1975):105-108.

Unless a firm knowledge on K exists it is dangerous to assume a priori the value for the length of the lag. Pagano and Hartley[21] point out that the procedure for determining a suitable degree of the polynomial, given K, can be used to find the optimal value of K. This may be done by calculating equation (30) with the K set at a fairly high value which is reduced sequentially until the null hypothesis (i.e., that the lag length is less than or equal to K) is rejected. After the value of the lag length is determined, then it can be used to find the degree of the approximating polynomial by utilizing the same procedure.

Of the three dynamic models, the Almon model seems to perform well and is relatively superior compared to the partial adjustment model and adaptive expectations model in estimating demand for forest products as indicated in some recent studies in this area, which will be reviewed below.

E. Review of Selected Literature

There have been a significant number of studies undertaken on estimation of demand for forest products in both the national and international levels. The emphasis of this section, however, is to review selected empirical studies which involved such intermediate products as logs and plywood.

In two separate studies, Chou and Buongiorno analyzed the relative importance of factors influencing import demand for hardwood plywood in the United States. The first study[122] is based on derived demand concept in which the demand for imports (of hardwood plywood) is a function of the activity in the construction industry. A derived demand function is generated on the premise that the industry minimizes costs subject to a generalized Cobb-Douglas production function, and then it is modified to reflect dynamic adjustment of imports in the short term. Utilizing Cagan's adaptive expectations model and Almon's polynomial distributed lag model, Chou and Buongiorno concluded that the latter is superior to the former model in terms of overall fit, minimum residual sum of squares, significant coefficients, and non-existence of serial correlation. In the three adaptive expectation demand models fitted, only the price of imported hardwood plywood and housing starts appeared to be statistically significant and the remaining explanatory variables (domestic price of hardwood plywood, domestic price of softwood plywood, and producer price of all commodities) were insignificant. Results from these three models also revealed that the use of either customs, free alongside ship (f.a.s.), or cost, insurance and freight (c.i.f.) data have no significant effect on statistical results. Moreover, the authors noted that the price term is best expressed in terms of the ratio of import price relative to the producer price of all commodities. This simply means that the assumption of no money illusion could not be rejected with the data used (monthly data for the period January 1974 to December 1979). However, it may be noted too that the basis of that claim (i.e., no money illusion) was not really strong as the test was carried out in a less systematic manner.[123] All the four adaptive expectations models did not indicate significant serial correlation. As stated earlier implicit in these types of models is the assumption that the expectations coefficients are the same for all the explanatory variables. In empirical work, such assumption is very restrictive because the response to changes in domestic prices may be faster than when the change occurs in the import price. To verify the veracity of this assumption, the authors used the polynomial distributed lag demand model but constrained to zero at the extreme points. Chou and Buongiorno found the latter model more preferable than Cagan's model. The short-term elasticity of imports with respect to real price was -.60(±.18) and 0.58(±.15) with respect to housing starts. Using the polynomial distributed lag model, the long-term elasticities obtained for the same explanatory variables were -1.98(±0.24) and 1.10(±0.12), respectively, with maximum lag of nine months and a mean lag of 4.5 months.

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[21] M. Pagano and M. Hartley, op. cit., p. 178.

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[122] See J. Chou and J. Buogiorno (1982).

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[123] In deciding whether the zero-degree homogeneity postulate is acceptable, the authors used an F test on the sum of squares of the residuals for their models (10) and (9-3) and concluded that the restrictions imposed by model (10) could not be rejected. Model (9-3) however contained other nonsignificant variables, as mentioned above, which were not included in model (10), and this author suspects that the presence of such variables could have inflated the problems associated with statistical results in model (9-3). Unless model (9-3) is modified, then this and model (10) cannot be directly compared.

The second study of Chou and Buongiorno[124] is specifically aimed at developing demand functions for hardwood plywood imports distinguished by country of origin. Nevertheless they estimated a model of the aggregate demand for imports, equivalent to polynomial distributed lag model, but used CES import quantity and price indices instead of the total quantity of hardwood plywood imported and c.i.f. price index (used in the first study). As in the first study, the coefficients of the lagged real price and housing starts were restricted to lie on a second degree polynomial constrained at the extreme points. An interesting result of this study is that the import elasticity with respect to housing starts was similar to the one obtained in the first study, despite the differences in the measurements used for quantity and import price variables. The elasticity with respect to real price was relatively higher, in absolute value, when CES indices were used. Unfortunately nothing was mentioned about the residual statistics from which one can gain some knowledge about the relative significance of the data measurements.

In McKillop's study[125] of forest products trade between North America and Japan, covering the period from 1950 to 1970, the level of residential construction and stocks of logs or lumber in Japan as well as the prices of competitive types of wood products, were found to have major influence in Japanese demand for the U.S. logs and lumber and for Canadian lumber. Using a number of single, linear demand equation and OLS, McKillop found that Japanese demand for North American logs and lumber was perfectly inelastic. Quite interestingly, neither the export prices (lagged or unlagged) of U.S. logs and lumber nor of Canadian lumber were significant in all demand equations fitted. McKillop found a rationale for this result : "that price is relatively unimportant on the demand side of the Japanese export market."[124] The results also indicated that the level of residential construction in Japan influences the country's current demand for wood imports by its current and previous (lagged by one quarter) levels. As judged by its price, wood imports from the Philippines seem to be a strong substitute for U.S. logs and lumber in Japan's market. All the demand equations show high coefficients of determination adjusted for the degrees of freedom, although nothing is mentioned about serial correlation and multicollinearity problems.

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[124] J. Chou and J. Buongiorno, (1983).

[125] W. McKillop, "Structural Analysis of Japanese-North American Trade in Forest Products," *Forest Science*, 19(1973): 63-74.

Through the years the focus of research in forestry has shifted from the issue of substitution (or complementarity) among wood products to substitution (or complementarity) between wood products and other factor inputs in the construction industry. The key factors that have motivated this shift have been discussed in part in Chapter 2 and partly in this chapter, such as the revisions in building code regulations, changes in relative prices and technological developments in both the wood and competing (i.e., metal and plastic) industries, among others. Adams and Blackwell[127] in their estimates of demand for plywood (softwood and hardwood) in the United States included a lagged price of plywood relative to a weighted price of substitute materials (i.e., building paper and board, fabricated structural metal products, etc.) and found that it was statistically significant. Results of the study suggested that plywood and lumber are substitutes during the period 1949-69, even though the plywood demand function (2) has shown a strong positive autocorrelation. Similarly, plywood and the weighted materials were found to be substitutes.

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[124] Ibid, p. 72.

In 1974 Mills and Manthy[128] analyzed the softwood lumber markets in the United States. Using primarily single, linear demand equation and 2SLS, they found the softwood plywood to be "a strong lumber substitute in the 'structural species' demand equation." [129] Moreover, as this study utilized annual data from 1947-70, it confirms the results obtained by Adams and Blackwell. Both studies suggested however that the price of softwood lumber is unimportant in the determination of its demand.

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[127] F.G. Adams and J. Blackwell, "An Econometric Model of the United States Forest Products Industry," *Forest Science*, 19(1973):82-96.

[128] T.J. Mills and R.S. Manthy, *An Econometric Analysis of Market Factors Determining Supply and Demand for Softwood Lumber*, Michigan State University Agricultural Experiment Station, East Lansing, 1974, 59 p.

[129] Ibid, p. 14.

The effects of prices of structural steel, aluminum, building board and labor wages (i.e., carpenter wages) on the demand for softwood lumber and plywood were also investigated by McKillop, Stuart and Geissler in 1980, using a longer annual time series (1947-74). In the plywood demand function, labor was found to act as a substitute for plywood, and along with the plywood price were statistically different from zero at the 95 and 99 percent confidence level, respectively. The price of building board did not seem to affect the plywood demand. In contrast, none of the competing factor inputs, as mentioned above, appear to be significant in the softwood lumber demand function, not even the plywood price. Despite the less significance of labor (carpenter wages), its negative coefficient indicates that it is likely a complement for softwood lumber. Like Adams and Blackwell, and Mills and Manthy, the present authors have failed to obtain significant price coefficients for softwood lumber. All the demand functions for wood products have high coefficients of determination adjusted for degrees of freedom and indicated no serial correlation. One might suspect however that multicollinearity did exist in the softwood lumber and plywood demand functions because of the many explanatory variables that are likely multicollinear, such as the index of industrial production and total housing starts.

The 1982 study of Rockel and Buongiorno utilized a translog cost function to specify the derived demand functions for softwood lumber, plywood, hardboard and particleboard, other materials [130] and labor. The method of sequential hypotheses testing was applied, wherein the most general cost function was tested against different and increasingly restrictive models, to determine the appropriate characteristics of production technology in the United States residential construction industry. Using an F test on the sum of squares of the residuals for the models in question, the authors chose the cost function that is of generalized Cobb-Douglas type. This particular cost function provided the derived demand functions estimated. The partial elasticities of substitution disclosed that all the above-mentioned factor inputs were substitutes during the period 1968-77. This result was not surprising because of the inherent characteristics of the Cobb-Douglas function. All the own-price elasticities of demand have the expected negative signs and were significantly different from zero at the 99 percent confidence level. There are a number of points that should be noted, however. For instance, the testing of the different models was carried out using only the cost function. Using OLS to estimate the parameter coefficients, one will readily suspect that the parameter estimates would be unstable and hence unreliable. This was evident in the many variables (parameters) in the cost function, which in most cases appear to be highly collinear. However, "the lack of data on the share of each input in the cost of residential construction,"[131] prompted the authors to use the cost function alone, instead of estimating the cost function along with the share equations. Likewise it should be noted that the cost variable was proxied by the Boeckh index of building cost for residences. Such proxy variable may therefore include some costs not attributed to any of the factors considered in the study (i.e., cost of paint). This suggests that the cost variable used might have overestimated the sum of the cost shares of the factor inputs included in the study. Rockel and Buongiorno further noted the presence of some positive autocorrelation and multicollinearity.

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[130] The composition of other materials is given in M.L. Rockel and J. Buongiorno, op. cit., p. 207.

Doran and Williams[132] in their study of the demand for domestically-produced sawn timber in the residential construction industry in Australia, between 1956 and 1977, used Diewert's cost function. Unexpectedly, the own-price elasticity of demand for domestic timber was positive, but they attributed this result to the method used in calculating the elasticity which was sensitive to the relationships of the omitted variables and domestic timber. Furthermore, the domestic timber, imported timber, bricks and plaster products appeared to be complements, while labor was a strong substitute for domestic timber. Doran and Williams also found imported timber to be a potential substitute for bricks in the residential construction. On the basis of the poor significance of the output coefficient, the authors inferred that constant returns to scale may exist in the construction industry.

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[131] Ibid, p. 211.
[132] H.E. Doran and D.F. Williams, (1982).

It may be noted that most of the available literature on forest products demand had been done in the United States and almost nothing concerning the South Korea and Japan. The present study is therefore an attempt to fill this gap.

F. Summary

The chapter has discussed the two demand theories that have been used in the formulation of the different analytical models of demand for forest products. It also outlined the procedure in determining the appropriate characteristics of production technology in the residential construction industry and the derivation of factor demand functions using the translog cost function and Shephard's lemma. Due to the importance of lags in demand adjustment as a result of a change in one of the factors that shift the demand curve, some of its sources were noted, and the models utilized frequently to capture such delayed response were reviewed. To acquire first hand information concerning the performance of some of the demand models reviewed as well as the relationship of logs and plywood to other factor inputs, this chapter reviewed some of the most recent empirical works in this area. The import demand models and the estimation techniques employed in the present study will be presented in the next chapter.

IV. IMPORT DEMAND MODELS, ESTIMATION PROCEDURES AND THE DATA

A. Introduction

This chapter will present the theoretical framework for the study as well as the final forms of the import demand models used in econometric analysis. It will also discuss the procedures in selecting the appropriate models and the techniques employed in estimating the models. The latter part of the chapter will introduce the data utilized in this particular study. Data problems however constrained the application of the translog cost function to derive import demand elasticity only for the United States. Apart from this the rest of the models are fitted each for Japan, South Korea and the United States.

B. Theoretical Framework

The appropriateness of the derived demand theory to forest products demand studies leads to its application as a guide in the construction of import demand models and the selection of important variables for inclusion in specific demand relationships. Realistically, the models should account for all the factors influencing the users of imports of hardwood logs or plywood and hence would require the incorporation of such sectors as construction firms, secondary or tertiary processing (or manufacturing) firms, and households. The present study, however, takes a more specific approach in model building in that it concentrates on the import demand of the principal users because of data and computational limitations. Furthermore, this approach conforms with the findings of the country analysis in Chapter 2 that the principal user or dominant wood using sector tends to influence the product structure and quantity requirements of import demand. This approach could therefore be expected to yield better results. The principal users as defined here refer to those who use a large proportion of imports either in their "original" form, as in the case of hardwood plywood imports, or in "processed" form, as in the case of imported hardwood logs converted - into - lumber (or plywood) in the importing country. This definition recognizes the fact that some imports are re-exported and therefore the specific models would contain some variables that provide a link between the principal user and the consuming sector in the final importing country. Such variables will allow the testing whether an increase or decrease in their values might have a proportional effect on the demand of the principal user for imports. Records indicate that the most important forest products industry in South Korea - the plywood manufacturing industry - obtained a large amount of its log inputs from the ASEAN countries (see Chapter 2).[133] For almost the same period, more accurately between 1967 and 1977 (except in 1974), the industry's exports of plywood were always more than 70 percent of the annual total production, with the United States having the greatest share. In view of this it may be reasonable to expect that the level of residential construction activity in the United States will appear in the import demand function of the forest products industry in South Korea. It follows too that the said industry is the principal user of hardwood log imports in South Korea.

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[133] For more infomation regarding South Korea's imports of forest products especially in the last four years, see Forestry Administration, *Forestry Development*, Seoul, South Korea, (undated), 64 p.

The residential construction industry appears to be the principal user of hardwood log imports (although in processed form) in Japan and of hardwood plywood imports in the United States, as evident in the discussion in Chapter 2. The influence of manufacturers of secondary wood products (i.e., lumber and plywood) in Japanese import demand may not be considered because of their minor role compared with the principal user. Evidence also suggests that the level of activity of residential construction industry determines the manufacturers' demand for hardwood log imports.[134] Thus it is more desirable to put emphasis on the principal user. Section E in Chapter 2 and Section E in Chapter 3 have noted possible explanatory variables which influence the demand for forest products imports in the three countries under consideration.

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[134] The importance of residential construction in timber (log) demand in Japan can be discerned from the articles of Z. Kawamura, "Lumber Industry Should Cope With Less Supply Against Recession," *Japan Lumber Journal*, 32 (Jan. 31, 1982), p. 12; A Gunji, "For Greater Timber Demand A Study of Changes in Housing Styles Needed," *Japan Lumber Journal*, 24 (Jan. 15, 1983), pp. 13 and 15; and the *Japan Lumber Journal*, "Demand for Southsea Logs for 1983, Hitting Bottom with Slight Decline After Continuous Big Fall Till 1982," 24 (Jan. 15, 1983), pp. 1-5.

In the specification of theoretical relationships which support the different import demand models to be discussed below, there are two procedures used. The first procedure derives demand relationships (and hence import demand functions) based on the classical assumptions of monoperiodic production function, perfect competition in factors market, cost minimization (or profit maximization), and perfect knowledge of the pertinent economic and technological data. Recognizing the fact that information may not be available at all times and that there exist some constraints which cause rigidity in behavior, the second procedure attempts to consider lags in demand formation. The two procedures result in two broad categories of import demand models. The first group of models are static in version, and all but one of them are specified in single equation. The only exception concerns the use of the translog cost function jointly with the cost share equations in the estimation of demand parameters for hardwood plywood imports in the United States. The other group of models deal with dynamic behavior which introduce lagged values either of dependent or independent variables, and are formulated in single equation form. Except for multivariate system of equations model, all other models are fitted separately for Japan, South Korea and the United States. The different alternative import models postulated for the three countries are summarized in Table 4.1. In the succeeding sections these models will be discussed in more detail.

Table 4.1. Alternative Import Demand Models[1]

United States	South Korea	Japan
1. Nonhomothetic translog model[2]	1. Single equation static demand model (1) $ML_t = f(PML_t)$ (2) $ML_t = f(PML_t, INP_t)$ (3) $ML_t = f(PML_t, INP_t, POM_t)$ (4) $ML_t = f(PML_t, INP_t, POM_{t-1})$ (5) $ML_t = f(PML_t, INP_t, POM_t, QUS_t)$ (6) $ML_t = f(PML/POM_t)$ (7) $ML_t = f(PML/POM_t, INP_t)$ (8) $ML_t = f(PML_t, INP_t, D_{1t}, D_{2t}, D_{3t})$ (9) $ML_t = f(PML_t, INP_t, POM_t, D_{1t}, D_{2t}, D_{3t})$	1. Single equation static demand model (1) $ML_t = f(PML_t, PDL_t, Q_t)$ (2) $ML_t = f(PML/PDL_t, Q_t)$ (3) $ML_t = f(PML_t, PDL_t, Q_t, D_{1t}, D_{2t}, D_{3t})$
2. Single equation static demand (1) $MP_t = f(PMP_t, Q_t)$ (2) $MP_t = f(PMP_t, Q_t, POM_t)$ (3) $MP_t = f(PMP_t, Q_t, POM_t, PK_t)$ (4) $MP_t = f(PMP_t, Q_t, POM_t, PK_t, PDP_t, T)$ (5) $MP_t = f(PMP_t, Q_t, POM_t, PK_t, PDP_t, PLU_t, T)$ (6) $MP_t = f(PMP_t, Q_t, POM_t, PK_t, T)$	2. Partial adjustment demand model (1) $ML_t = f(PML_t, ML_{t-1})$ (2) $ML_t = f(PML_t, INP_t, ML_{t-1})$ (3) $ML_t = f(PML_t, INP_t, POM_t, ML_{t-1})$	2. Partial adjustment demand model (1) $ML_t = f(PML_t, PDL_t, Q_t, ML_{t-1})$ (2) $ML_t = f(PML/PDL_t, Q_t, ML_{t-1})$
3. Partial adjustment demand model (1) $MP_t = f(PMP_t, Q_t, MP_{t-1})$	3. Polynomial distributed-lag demand model (1) $ML_t = f(\text{Almon lag on } PML_t \text{ and } INP_t)$	3. Polynomial distributed-lag demand model (1) $ML_t = f(\text{Almon lag on } PML_t \text{ and } Q_t)$
4. Polynomial distributed-lag demand model (1) $MP_t = f(\text{Almon lag on } PMP_t, Q_t, POM_t, PK_t \text{ and } PLU_t)$		

Notes: 1. See definitions of variables in Table 4.2.

2. Refer to equation 36 below. Note that in the estimation of model 1, the nonhomothetic translog cost function will be calculated jointly with n-1 share equations. In addition model 1 is subject to the outcome of hypothesis testing (see section F below) and as such may change in the final estimation.

Table 4.2. Definitions of Variables

Variable	Definition
United States	
MP	Quantity index of hardwood plywood imports for each quarter, 1967-83, from the ASEAN countries.
PMP	Weighted average Divisia price index of hardwood plywood imports.
POM	Aggregate Divisia price index of fabricated structural steel and portland cement.
PK	Average quarterly home mortgage rates Divisia index, used as a measure of the price of capital.
PDP	Divisia price index of softwood plywood.
PLU	Divisia price index of Douglas-fir lumber.
PL	Average weekly earnings Divisia index of special trade construction workers, used as a measure of the price of labor in residenatial construction.
Q = Y	Index number of new housing units commenced in each quarter.
T	Time, = 1 in the first quarter of 1967.
MP_{t-1}	Quantity index of hardwood plywood imports, lagged one quarter.
South Korea	
ML	Quarterly average volume index of hardwood log imports for each quarter, 1970-78, from the ASEAN countries.
PML	Weighted average price index of hardwood log imports.
POM	Producer price index for a representative list of commodities used as a proxy for the price of other intermediate products.
INP	Index of industrial (manufacturing) production.
QUS	Index number of new housing units started in the United States.
ML_{t-1}	Quarterly average volume index of hardwood log imports, lagged one quarter.
POM_{t-1}	Producer price index, lagged one quarter.
D_{1t}, D_{2t}, D_{3t}	Dummy variables.
Japan	
ML	Quarterly average volume index of hardwood log imports from the ASEAN countries, 1979-83.
PML	Weighted average price index of hardwood log imports.
PDL	Average domestic wholesale price index of lauan logs in Tokyo.
ML_{t-1}	Hardwood log imports, lagged one quarter.

C. Models Postulated for the United States: Demand for Hardwood Plywood Imports

Static Import Demand Models

Model 1 - The first model refers to the nonhomothetic translog cost function introduced in Chapter 3. Following Burgess,[135] Kohli,[136] and Andersson et al,[137] imports of hardwood plywood (MP) are assumed to be used along with other factor inputs, by profit maximizing residential construction industry in the production of residential units. The other factor inputs include labor (L), capital (K), domestically-produced softwood plywood (DP, hereafter domestic plywood), and domestically-produced softwood lumber (LU, hereafter domestic lumber).[138] Inputs of other materials (i.e., structural steel, cement, bricks, etc.) are not considered in the final estimation because of the difficulty arising from the construction of aggregate price and quantity indexes, if ever aggregation is possible. Consequently, the five factor inputs mentioned above are as a group taken as weakly separable from the other material inputs. This means that the MRS between any two of the five factor inputs is independent of the quantity of other materials utilized as inputs. In such a case the production function for the industry can be written in the form :

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[135] See D.F. Burgess, "A Cost Minimization Approach to Import Demand Equations," *Review of Economics and Statistics* LVI (1974a): 225-234; "Production Theory and the Derived Demand for Imports," *Journal of International Economics*, 4(1974b): 103-117; and "Duality Theory and Pitfall in the Specification of Technologies," *Journal of Econometrics*, 3(1975): 105-121.

[136] See U.R. Kohli, "A Gross National Product Function and the Derived Demand for Imports and Supply of Exports," *Canadian Journal of Economics*, XI(1978): 167-182; and Production Theory, Technological Change, and the Demand for Imports," *European Economic Review*, 18(1982): 369-386.

[137] See A.E. Andersson et al (1985).

[138] These factor inputs are defined below.

$$Y = F\,[f(L, K, MP, DP, LU); OM] \qquad (33)$$

where Y is the level of residential output, which is represented by the number of housing starts. L, K, MP, DP and LU are as defined previously, while OM refers to other materials. This production function F should be at least twice differentiable in inputs, increasing with Y and decreasing with inputs, and strictly quasi-concave.

Since the residential construction industry competes with other manufacturing industries in the purchase of factor inputs, it is necessary to suppose that the former faces perfect competition in factors market. Furthermore, the level of residential output is assumed to be determined prior to the purchase of inputs in time t in view of the building contracts that usually extend over a quarter, or even more than a year for large residential construction projects. If the foregoing assumptions hold, then the production function (33) can be adequately represented by a cost function that is also weakly separable in inputs, using the property of duality, with the form :

$$C = C\,[c(PL, PK, PMP, PDP, PLU, Y); POM, Y] \qquad (34)$$

where C is total production cost, which is the sum of total expenditures attributed to each factor inputs. The P's are prices of inputs defined in (33). To ensure that the cost function (34) is a well behaved function, it should at least be twice differentiable with respect to input prices, continuous, concave, positive linear homogenous in input prices and nondecreasing in output.

The derived demand functions for imported hardwood plywood and other inputs can be readily obtained using Shephard's lemma :

$$X_i = \partial C / \partial P_i \qquad (35)$$

for i = L, K, MP, DP, LU; where X_i is the derived demand for input i. Notice that equation (35) is generated from a very general cost function (34) which does not indicate the appropriate functional form and therefore (35) is not at its present form suitable for estimation. Likewise equation (34) provides nothing about the relevant aspects of production technology underlying the industry. Since economic theory provides little guidance in the choice of appropriate functional form, this becomes an empirical problem. To overcome this difficulty, a nonhomothetic model of translog cost function (16) is postulated to provide a framework for testing the various possible alternative technologies, and to derive the final form of cost function and cost-minimizing input share demand equations. Instead of estimating the derived demand functions such as (35) to obtain demand elasticities, the present study utilizes the parameter estimates of the multivariate system of equations (the translog cost function and share equations).

For estimation purposes the nonhomothetic model for the five inputs-single output technology can be rewritten in stochastic form as :

$$\begin{aligned} \ln C = {} & \gamma_0 + \Sigma_i \gamma_i \ln P_i + (1/2)\, \Sigma_i \Sigma_j \gamma_{ij} \ln P_i \ln P_j \\ & + \gamma_Y \ln Y + (1/2)\, \gamma_{YY} (\ln Y)^2 + \Sigma_i \gamma_{iY} \ln P_i \ln Y \\ & + \gamma_t t + (1/2)\, \gamma_{tt}\, (t)^2 + \gamma_{Yt} \ln Yt \\ & + \Sigma_i \gamma_{it} \ln P_i t + u \end{aligned} \qquad (36)$$

for i,j = L, K, MP, DP, LU. The time variable t serves as a proxy for technical change. The addition of the disturbance term u reflects errors in optimizing behavior of the industry arising from its inability to operate at all times in a cost-minimizing expansion path due to some factors mentioned in the earlier chapters (i.e., changing relative factor prices, revisions in building regulations, etc.).

Given the condition that perfect competition exists in the inputs market, differentiation of the nonhomothetic translog cost function (36) with respect to the input prices will yield the market share S of the input i. The resulting input share mand equations given in equation (17), can be rewritten as:

$$S_i = \gamma_i + \Sigma_j\, \gamma_{ij} \ln P_j + \gamma_{iY} \ln Y + \gamma_{it} t \qquad (37)$$

It is likely that the disturbance terms across input share demand equations are correlated as a consequence of the restriction, by definition, that the sum of each input cost shares must add to one. To take this into account explicitly during the actual estimation process will improve the efficiency of the parameter estimates. However, this necessitates additional parameter restrictions such that the sum of the intercept coefficients is equal to one and that the sum of the slope (elasticity) coefficients is zero. Moreover these restrictions require the estimation of only four of the five share equations (37). This leads to the omission of domestic lumber share equation. Consequently, linear homogeneity in input prices forms as a maintained hypothesis in the present model. For the omitted share equation (SLU), the implied parameter estimates can be solved directly from the calculated parameters of the four share equations.

Implicit in the remaining four share equations are symmetry restrictions on the input price parameters which lead to the reduction of the number of independent parameters from 35 to 24. Equations (36) and (37) comprise Model 1,[139] and will be jointly utilized to determine the appropriate characteristics underlying the technology and to estimate demand elasticities for the imported hardwood plywood and other factor inputs. The simultaneous estimation of the input share demand equations has a theoretical advantage in that it is consistent with optimal behavior of the industry. A cost minimizing industry, for instance, would be expected to decide simultaneously on the optimal combination of inputs rather than separately on each input to minimize cost, subject to technology, input prices and the level of output. The estimation technique and the procedure for the sequential hypotheses testing of nested models will be discussed in the next section.

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[139] Model 1 is subject to the outcome of hypothesis testing (see Section F below) and as such may change in the final estimation.

Inasmuch as Model 1 cannot be used for Japan and South Korea due to inaccessibility (or unavailability) of the required data, it is deemed necessary to postulate models which can be fitted each for the three importing countries of interest in this study. The resulting import demand models are essentially partial equilibrum models in which the focus of analysis is only on the demand for imports. One might expect some simultaneity bias in the parameter estimates obtained from single equation estimation of import demand. In order to minimize the impact of this bias on the inference procedures some specific assumptions are made. Foremost among these is the usual assumption that exports supply is infinitely elastic. As Buongiorno et al stressed, this postulate "eliminates possible correlation between the error term and the price of imports."[140]

Model 2 - This model considers the industry to have a distinct demand function for hardwood plywood imports. Further, it assumes that plywood imports are not a perfect substitute for domestic plywood as input in the production process. The latter assumption recognizes the fact that "in the United States..., softwood plywood is used in applications generally different from those of hardwood plywood."[141] There are also other reasons which require the distinction between plywood imports and domestic plywood such as differences in species composition, quality, and the like.

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[140] J. Buongiorno, J. Chou and R.N. Stone, "A Monthly Model of the United States Demand for Softwood Lumber Imports," *Forest Science* 25(1979), p. 646.

As in model 1, it is postulated that the demand for hardwood plywood imports is a derived demand and thus its demand can be expressed as a function of (i) the level of residential output, (ii) the price of domestic plywood, (iii) the prices of all other inputs, and (iv) the import price of hardwood plywood. The influence of technical change is accounted for by the inclusion of a time term as an explanatory variable. In the estimation of single, import demand equations, there are two main issues involved. First, what specific functional form fits best for the data on explanatory variables? Second, which of the possible explanatory variables should be included in each specification of import demand? Previous studies suggest that the log-linear form is preferable to the linear form and thus it is adapted in the present model. The use of this particular form function is also desirable since its parameters provide direct estimates of import demand elasticities which may be comparable with those in the first model. The second issue is related to the problems of multicollinearity and specification errors. Basically, there are many possible explanatory variables that could be included in the model but doing so will result in serious multicollinearity. On the other hand, omitting some variables in order to avoid the effects of collinearity among explanatory variables will more likely introduce specification error in the model. The next section will further elaborate on these problems and present the procedures employed to arrive at a more appropriate import demand model. An appropriate model is defined by Thursby and Thursby "as one which generates unbiased (or at least consistent) and efficient elasticity estimates, even though that model may not be a 'true' representation of import demand."[142]

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[141] Ibid, p.231.

Six submodels of increasing number of independent variables are developed in this model, with all of them being static in version (Table 4.1). The first submodel relates the quantity demanded of hardwood plywood imports (MP) in period t to the level of residential output and the import price of that product in the same period. The log-linear form of submodel 1 states that :

$$\ln MP_t = a + b\ (\ln PMP)_t + c\ (\ln Q)_t + u_t \qquad (38.1)$$

in which t represents a particular quarter and where t = 1,2,...,68. PMP is the weighted average import price and Q is the level of residential output. The u is a random error term assumed to be normally and independently distributed with zero mean and constant variance. The coefficients b and c can be interpreted as demand elasticities of hardwood plywood imports with respect to residential output and import price respectively. On an a priori basis, one would expect the sign of b to be negative since an increase in import price, other things being equal, will result in a decrease in imports. In general, however, the level of imports should rise as the residential activity increases and hence one would expect c to be positive.

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[142] J. Thursby and M. Thursby, "How Reliable Are Simple, Single Equation Specifications of Import Demand," Review of Economics and Statistics, LXVI(1984) : 120-128.

Submodel 1 does not account for substitutability or complementarity between imported hardwood plywood and other factor inputs and as such, it may yield biased estimates due to specification errors in the parameters. To reduce, if not totally eliminate, the consequences of specification error, the subsequent submodels include other factor inputs. As early estimates (see Chapter 3, Section E) have indicated that the price of domestic plywood, whether softwood or hardwood species, is insignificant in determining demand for hardwood plywood imports, submodel 2 instead assumes that substitution or complementarity exists between imported plywood and other non-wood construction materials. This takes the form :

$$\begin{aligned} \ln MP_t &= a + b\,(\ln PMP)_t + c\,(\ln Q)_t \\ &\quad + d(\ln POM)_t + u_t \end{aligned} \tag{38.2}$$

where POM is an average price of other construction materials, consisting of fabricated structural steel and portland cement. Since both the imported plywood and these other non-wood materials are utilized in construction activity, one would expect that they will behave as complements. As a result, the coefficient d should be negative. Capital being a primary input in construction activity is introduced in submodel 3, and is postulated to act as a substitute for imported plywood. As will be discussed in detail in the latter section, capital is represented by the quarterly average of new mortgage loans extended by all Savings and Loan Associations for home construction purposes. Similarly, its price is measured by the average mortgage rates for new home purchases. Evidently, if the price of capital (PK) increases, the price of residential units may also rise. As a result, many households may not be able to purchase their desired types of residential units and this would affect the residential construction industry. In an attempt to induce households to buy residential units, the industry would tend to substitute relatively cheaper inputs such as imported plywood for capital to enable it to sell its output (residential units) at a reasonable price. Thus the coefficient associated with PK should have a positive sign. Submodel 3 states that :

$$\ln MP_t = a + b\,(\ln PMP)_t + c\,(\ln Q)_t + d(\ln POM)_t + e\,(\ln PK)_t + u_t \qquad (38.3)$$

In submodel 4, the influences of domestic plywood and technical change on the derived demand for hardwood plywood imports are considered. If technical change is input saving in imported plywood, the coefficient associated with time variable T, used as a proxy for it, would be negative. Available literature suggests that the imported plywood should be treated as a complement to domestic (softwood) plywood. Whether this suggestion is valid depends on the coefficient of the price of domestic plywood (PDP). Submodel 4 thus takes the form :

$$\ln MP_t = a + b\,(\ln PMP)_t + c\,(\ln Q)_t + d(\ln POM)_t + e\,(\ln PK)_t + f(\ln PDP)_t + hT + u_t \qquad (38.4)$$

The coefficient f would be negative if imported plywood and domestic plywood behave as complements in the production function of the industry. h is the coefficient reflecting the effect of technical change on the level of plywood imports.

Submodel 5 expands submodel 4 by adding domestic lumber as an explanatory variable in the import demand function. No study seems to have looked into the substitution or complementarity relationship between imported hardwood plywood and domestic lumber in residential construction and therefore submodel 5 is an attempt to examine it. It states that :

$$\ln MP_t = a + b\,(\ln PMP)_t + c\,(\ln Q)_t + d(\ln POM)_t + e\,(\ln PK)_t + f(\ln PDP)_t + g(\ln PLU)_t + hT + u_t \qquad (38.5)$$

where PLU is as defined previously. A positive (negative) sign on the coefficient g would mean that plywood imports and domestic lumber are substitutes (complements).

Submodel 6 postulates that import demand for hardwood plywood depends largely on its price, the price of non-wood construction materials, the price of capital, the level of output, and technical change. This leads to the following relationship among observable variables:

$$\ln MP_t = a + b\,(\ln PMP)_t + c\,(\ln Q)_t + d(\ln POM)_t + e\,(\ln PK)_t + hT + u_t \qquad (38.6)$$

One would expect all coefficients in this submodel to have the same signs as in the previous submodels.

It may be worth noting the relevance and reason for the inclusion of this model. The formulation of model 2 arose out of several studies conducted in this area which have utilized single equation models to determine the demand for forest products. With the increasing availability of data, especially for the United States, it was deemed worthwhile to compare the estimates of a single equation model with that of a model comprising a system of equations in the hope that some significant information can be gained. Also, it has been the intention to examine whether omission of some relevant variables which may result to specification error will be a major source of bias on the estimated elasticities. A consequence of specification error due to omitted variables is the occurrence of higher than usual disturbance variance or standard errors associated with the parameter estimates. The ultimate effects of such error are biased parameter estimates. In the specification of the six submodels, the likelihood of specification error to exist can be determined by investigating the standard error of the elasticity coefficients in each submodel. For example, one can compare the parameter estimates and their corresponding standard errors of submodel 1 with those of submodel 4 since in the former case the explanatory variables are only two, while there are six in the latter case. In this case, if misspecification really exists, one would expect the elasticity estimates in submodel 1 to have overestimated standard errors and therefore the estimates themselves are biased.

Partial Adjustment Import Demand Model

Model 3 - The two previous models are based on the presumption that hardwood plywood imports are affected by current observed values of input prices and residential output. That is to say, demand for plywood imports is always adjusted instantaneously to the new equilibrum value when one of its determinants changes. Model 3 relaxes this assumption by specifying a partial adjustment mechanism for imports of hardwood plywood. It assumes that the actual volume of imports in a given quarter t is only partially adjusted to its desired level, due to some constraints outlined in Chapter 3, and such adjustment process is captured by introducing the level of imports in the previous period as an explanatory variable in the import demand function. Recalling the derivation of the partial adjustment import demand equation (equations (24)-(26)), model 3 states that:

$$\begin{aligned} \ln MP_t &= \beta a + \beta b(\ln PMP)_t + \beta c(\ln Q)_t \\ &\quad + (1-\beta)(\ln MP)_{t-1} + \beta u_t \end{aligned} \tag{39}$$

where t = 1,2,...,68 and β as before is the coefficient of adjustment (Table 4.1). The choice of explanatory variables in the present model is basically arbitrary and as in the case of submodel 1 in model 2, could be biased as a result of misspecification in the parameters. However, the exclusion or omission of some independent variables would be a major source of bias in model 3 only if they appear to be significant in the previous submodels (2 - 6) in model 2, not to mention model 1 which provides for interaction among factor inputs. This model is chosen instead of the adaptive expectations model since, it does not induce serial correlation if there was none to begin with.

Polynomial Distributed-Lag Import Demand Model

Model 4 - Model 3 still imposes restrictive assumptions on the adjustment coefficient which are taken to be the same for the import price and the level of residential output. The arguments presented in Chapter 3 made such assumptions and hence model 3 less desirable. Model 4 proposes a distributed lag import demand model attributed to Almon. This model assumes that current demand for hardwood plywood imports depends on the current and past levels of import prices, construction activity, price of capital, price of domestic lumber and price of other non-wood construction materials (Table 4.1). This takes the form (recall equations (30) - (32)):

$$\ln MP_t = a + \sum_{k=0}^{K} b_k(\ln PMP)_{t-k} + \sum_{k=0}^{K} c_k(\ln Q)_{t-k}$$

$$+ \sum_{k=0}^{K} d_k(\ln POM)_{t-k} + \sum_{k=0}^{K} e_k(\ln PK)_{t-k}$$

$$+ \sum_{k=0}^{K} g_k(\ln PLU)_{t-k} + u_t \qquad (40)$$

Unlike model 2 which imposes a priori a geometrically declining distributed lag, the present model can actually test the alternative possible distributed lags similar to the standard tests of linear hypotheses; the procedure used here will be explained later.

D. Models Postulated for South Korea: Demand for Hardwood Log Imports

As stated earlier, the forest products manufacturing industries rather than residential construction industry should be regarded as principal users of hardwood log imports in South Korea. This suggests that an index of industrial production particularly for said industries would be a major demand shifter. An initial examination of the predictive power of construction activity vis-a-vis index of industrial production supported the above observation. Results of the preliminary regression indicated that the level of residential construction represented by the number of new dwellings constructed each quarter, could not be accepted at 0.95 confidence level. Conversely, the index of industrial production was found to be highly significant (at 0.99 confidence level) when regressed to the volume of log imports. Hence the industrial production index is considered a principal determinant of import demand.

Static Import Demand Model

Model 1 - The basic assumption of model 1 is that imports of hardwood logs in a given quarter are determined by the production activity of the principal users in South Korea, aside from input prices. It assumes further that the principal users can be linked to the consuming sector of processed products in other importing countries through the inclusion of the level of output in construction in the latter in import demand function of the former. In the sample period considered the three major importers of South Korea's hardwood plywood were the United States, Europe and the Middle East. The model however, considers only the United States partly because its market for hardwood plywood seems to be more stable, as judged from its quarterly imports, and partly due to the availability of time series data. The fact that the United States appeared to be the largest importer of hardwood plywood makes it an important factor in demand analysis of hardwood log imports.

Nine submodels are formulated under this model (see Table 4.1). Each submodel seeks to examine either the significance of a particular explanatory variable to ensure that any effect it might have on import demand could be quantified, or the validity of a given assumption about the behavior of the principal users. The former characterizes the first five submodels in which each explanatory variables is introduced in succession into the model. Submodels 6 and 7 test the validity of the assumption about the absence of money illusion. As can be seen in Appendix 1, imports of hardwood logs show strong seasonal fluctuations with peaks mostly observed in the second and third quarters, while in many instances they were low at the beginning of the year (i.e., in the first quarter). Instead of smoothing the data to eliminate seasonal variation, the present model introduces dummy variables to capture such fluctuation. This is done so as not to disturb the real attributes of the data that may affect the estimated relationship.[143]

Submodel 1 assumes that the primary factor influencing the import demand for hardwood logs is its price. This can be written as :

$$\ln ML_t = a + b(\ln PML)_t + u_t \qquad (41.1)$$

for $t = 1,2,\ldots,36$; where ML is the volume of log imports in a given quarter t, and PML is a weighted average price of imports.[144] The random error term u is assumed to capture the influence of omitted explanatory variables, and provided such variables are not highly collinear with the import price the u shall possess its usual properties. Economic theory tells that the elasticity coefficient b should be negative. Obviously, PML is not the only factor the principal users consider in determining their demand for log imports. Submodels 2 and 3 postulate, respectively, that production activity and price of other intermediate products have substantial impacts in deciding the amount of imports to be actually ordered in a given period t. These submodels are:

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[143] K.F. Wallis, "Seasonal Adjustment and Relations Between Variables," *Journal of American Statistical Association*, 69(1974) : 18-31.

[144] The procedure in deriving a weighted average import price is given in Section G of the present chapter.

$$\ln ML_t = a + b(\ln PML)_t + c(\ln INP)_t + u_t \tag{41.2}$$

and

$$\ln ML_t = a + b(\ln PML)_t + c(\ln INP)_t + d(\ln POM)_t + u_t \tag{41.3}$$

Here, POM is South Korea's producer price index for a representative list of commodities used as an indicator of price of other intermediate products, and INP is an index of industrial (manufacturing) production. A rise in production of secondary wood products such as plywood and lumber will result in an increase in log imports, and thus c should be positive. In the manufacture of plywood, for example, other intermediate inputs are required such as various types of adhesives which specify the proper end-usage of the product (i.e., casein and soya for interior plywood). Since imported logs and other intermediate inputs complement each other in plywood production, one would expect coefficient d to be negative.

Submodel 4 is based on the assumption that the level of imports depends on the current price of imported logs and production activity and the price of intermediate products in the previous quarter. This yields the following relationship:

$$\ln ML_t = a + b(\ln PML)_t + c(\ln INP)_t + e(\ln POM)_{t-1} + u_t \tag{41.4}$$

The coefficient e should be negative in keeping with the proposition noted above.

Submodel 5 extends submodel 3 by including the current level of residential construction in the United States. This new explanatory variable is expected to have a positive impact on current log imports through its direct influence in production of hardwood plywood. Thus the coefficient associated with the new variable should have a positive sign. Submodel 5 can be expressed as:

$$\ln ML_t = a + b(\ln PML)_t + c(\ln INP)_t + d(\ln POM)_t + f(\ln QUS)_t + u_t \qquad (41.5)$$

where QUS is the United States housing starts.

Sometimes the behavior of the industry in relation to its imports may exhibit no money illusion and this suggests that the import demand function is homogenous of degree zero in prices. That is, for a given level of production, principal users of hardwood logs would continue importing the same amount as before if all prices change by equal proportion. This assumption has often been made in the formulation of import demand models; for example, Chou and Buogiorno (1982, 1983) and Buongiorno et al(1979) used this in their studies of import demand for hardwood plywood and softwood lumber in the United States consecutively. But rather than impose such assumption as a maintained hypothesis it is more plausible to test its validity. Submodels 6 and 7 are designed to deal with this issue. Log imports are assumed to depend on the ratio of current import price to domestic price of other intermediate products and the level of production activity. Submodel 6 considers only the first explanatory variable and takes the form:

$$\ln ML_t = a + g(\ln PML/POM)_t + u_t \qquad (41.6)$$

with an expected negative sign for g. On the other hand, submodel 7 states that:

$$\ln ML_t = a + g(\ln PML/POM)_t + c(\ln INP)_t + u_t \qquad (41.7)$$

The acceptability of no money illusion constraint can be directly determined from the calculated value of coefficient g and its corresponding t-ratio or standard error.

Submodels 8 and 9 explore the likelihood of seasonality in import demand for hardwood logs. They are basically parallel to submodels 2 and 3 but now explicitly account for any systematic seasonal variation not captured by the existing explanatory variables by adding seasonal dummies. For estimation purposes they can be rewritten as:

$$\ln ML_t = a + b(\ln PML)_t + c(\ln INP)_t + hD_{1t} + iD_{2t} + jD_{3t} + u_t \qquad (41.8)$$

and

$$\ln ML_t = a + b(\ln PML)_t + c(\ln INP)_t + d(\ln POM)_t + hD_{1t} + iD_{2t} + jD_{3t} + u_t \qquad (41.9)$$

where D_{it} = 1 if t occursinquarter i; i = 1,2,3

= 0 if otherwise.

Any seasonal effect occuring in the fourth quarter should be accounted for by the constant intercept a, such that all the D's are zero in this particular quarter. If the earlier observation about the trend of log imports is due to seasonal effects, one can speculate that the coefficient of the first dummy variable h will be negative and the rest positive.

Partial Adjustment Import Demand Model

Model 2 - There are three submodels developed in model 2, each providing for partial adjustment in import demand. With the basic notion that log imports in the previous quarter affects current level of imports, in addition to current production activity and price variables, the three submodels yield the following relationships (Table 4.1):

$$\ln ML_t = \beta a + \beta b(\ln PML)_t + (1-\beta)(\ln ML)_{t-1} + \beta u_t \qquad (42.1)$$

$$\ln ML_t = \beta a + \beta b(\ln PML)_t + \beta c(\ln INP)_t + (1-\beta)(\ln ML)_{t-1} + \beta u_t, \qquad (42.2)$$

$$\ln ML_t = \beta a + \beta b(\ln PML) + \beta c(\ln INP)_t + \beta d(\ln POM)_t + (1-\beta)(\ln ML)_{t-1} + \beta u_t \qquad (42.3)$$

where β is the adjustment coefficient which takes a value between zero and one. The seemingly well adapted processing plants in South Korea for hardwood logs would justify the slow adjustment in log imports as a result of a change in its price. Being known for efficiency in plywood production, South Korean processors or manufacturers may bear the small change in import price while trying to improve their techniques to offset the additional costs on hardwood log imports and to remain competitive in world markets for processed wood products. This leads one to expect that the adjustment coefficient may yield an estimate that is approaching zero. On the contrary, one may also suspect for a value of β that is close to one considering the continually rising prices of processed wood products in export markets, and that would permit the industry to respond promptly to exogenous forces.

Polynomial Distributed-Lag Import Demand Model

Model 3 - Principal users of log imports may keep track of changes in input prices and production trends that they could make use in determining their present and future demands for factor inputs. In view of this it may well be reasonable to assume that their current imports are influenced by current import price and production activity but likewise by their speculation of the likely trends in input prices and production in the near future based on their past experience. The latter can be effectively captured by introducing lagged values of PML and INP. That is,

$$\ln ML_t = a + \sum_{k=0}^{K} b_k (\ln PML)_{t-k} + \sum_{k=0}^{K} (\ln INP)_{t-k} + u_t \qquad (43)$$

The values of Σb and Σc should be equal or close to their corresponding coefficients in model 1, since the two models provide equilibrum (long run) demand elasticities. Clearly, model 2 measures short run elasticities.

E. Models Postulated for Japan: Demand for Hardwood Log Imports

In 1983 Nomura and Yukutake [45] estimated the demand for timber in Japan using quarterly data for the period 1965-73 and found wooden construction starts, seasonal fluctuations and structural change as the most significant influencing variables. In contrast, the effect on demand of the ratio of wholesale timber price index to the general wholesale price index was discovered insignificant. Evidence of structural change occured in 1972 and 1973, and had the expected negative impact on timber demand. The effects of seasonal variation however were detected to have started in the second quarter, and all seasonal dummies except the intercept term reflecting the influence of the fourth quarter have negative coefficients. Construction starts have the expected positive coefficients. These results inevitably supply valuable information that could facilitate the selection of appropriate explanatory variables for inclusion in the demand relationships. The present study departs from the study of Nomura and Yukutake in the sense that its scope concerns only Japan's demand for hardwood log imports emanating from the ASEAN countries, while the latter looked on aggregate total timber demand. In addition this study seeks to analyze log import demand in the current period, more accurately 1979-83; however the author's inability to obtain sufficient time series data especially quarterly volume of log imports also accounts for the time period under consideration. Recourse to some approach to generate quarterly data such as the use of related series proposed by

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[45] I. Nomura and K. Yukutake, "Timber Price Movement in Japan Since World War II and Its Theoretical Causes," in R. Seppala, C. Row and A. Morgan (eds), *Forest Sector Models*

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[145] (cont'd) (Berkhamsted: A.B. Academic Publishers, 1983), pp. 335-344.

Friedman[146] turned out to give biased estimates of the dependent variables when compared with the available annual data. This leads to the use of the available quarterly series noted above. One consequence of the relatively short time series is that the number of possible explanatory variables may far exceed the restrictions implied by statistical theory. In order to take this into account a choice criterion is employed. The dependent variable is regressed on each of the possible candidates and only the significant ones are selected.[147] The selection is done after autocorrelation was corrected.

Static Import Demand Model

Model 1 - For Japan hardwood log imports, model 1 assumes that the residential construction industry derives its demand based on the current level of construction activity, the price of log imports and the domestic price of hardwood logs. Three submodels are developed here (see Table 4.1) and submodel 1 states that:

$$\ln ML_t = a + b\,(\ln PML)_t + c\,(\ln PDL)_t + d(\ln Q)_t + u_t \quad (44.1)$$

for t = 1,2,...,20; where ML is the quantity of log imports in period t, PML refers to the weighted average import price, PDL is the average price of lauan logs in Tokyo used as a proxy for average domestic price of logs in Japan, and Q is defined as the number of new residential housing started. As before, one should expect b and d to have negative and positive elasticity coefficients, respectively. The elasticity coefficient of PDL can be suspected to have a negative sign since a rise in the domestic price of hardwood logs may give incentive to the industry to substitute softwood logs or even other non-wood materials for log imports and hence result in the reduction in the quantity of imports.

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[146] M. Friedman, "The Interpretation of Time Series by Related Series," *Journal of the American Statistical Association*, 57(1962): 729-757.

[147] The following variables are considered in the selection of more appropriate and significant (in statistical sense) explanatory variables: (1) weighted average price of hardwood log imports, (2) domestic price of hardwood logs, (3) number of housing starts, (4) domestic price of hardwood plywood, (5) producer price of representative list of commodities, (6) index of industrial production, and (7) floor area of residential buildings measured to the outer surface of the outer walls.

Submodel 2 postulates that industry's demand behavior regarding log imports is free of money illusion and implies that:

$$\ln ML_t = a + e\,(\ln PML/PDL)_t + d(\ln Q)_t + u_t \qquad (44.2)$$

If an increase in import price leads domestic price of hardwood logs to rise, which is more likely, then the demand for log imports would tend to decline. This suggests that the coefficient e should be negative.

In view of the findings of Nomura and Yukutake submodel 3 examines the possibility of seasonal effects on import demand. This is carried out by expanding submodel 1 through the inclusion of three seasonal dummy variables. For estimation purposes submodel 3 is given as follows:

$$\ln ML_t = a + b\,(\ln PML)_t + c\,(\ln PDL)_t + d(\ln Q)_t$$
$$+ fD_{1t} + gD_{2t} + hD_{3t} + u_t \qquad (44.3)$$

Here, f, g, and h are expected to be negative.

Partial Adjustment Import Demand Model

Model 2 - As in the other two importing countries, partial adjustment in import demand is assumed in this model. Further, it postulates that the adjustment process can be effectively accounted for by including the actual quantity of log imports in the previous period as one of the arguments in the demand function. In Japan one of the primary sources of lags in the response of import demand to changes in various explanatory variables can be due to stock adjustments since inventories of both hardwood logs and processed wood products are a common practice in several levels of distribution channels. For example, there has been indication that home builders tend to secure stocks of plywood (of tropical logs origin) in the beginning of the year in anticipation of a rise in demand for housing during spring.[14] Consequently, with the traders (importers) also maintaining inventory of logs, and the manufacturers of processed products reluctant to purchase log imports and increase production level, the short run demand for hardwood log imports can reasonably be speculated to be adjusted only partially to its desired (long-run) level. This proposition seems justifiable in view of the time series considered in this study. Thus submodels 1 and 2 in model 1 are modified accordingly at this stage so as to consider the possible time lag involved in the adjustment of actual level of log imports to the desired level. The resulting partial adjustment import demand submodels can be expressed as:

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[14] See the following articles under the "Spotlight" section of the *Japan Lumber Journal:* (i) "Plywood: Demand Remains Poor," 19(April 7, 1981), p. 15; (ii) "Tropical Logs: Sharp Inventory Liquidation," 19(December 30, 1980), p. 19; and (iii) "Tropical Logs: Stock Liquidation Stops," 19(June 9, 1981), p. 15.

$$\ln ML_t = \beta a + \beta b\,(\ln PML)_t + \beta c\,(\ln PDL)_t + \beta d(\ln Q)_t + (1-\beta)(\ln ML)_{t-1} + \beta u_t \qquad (45.1)$$

and

$$\ln ML_t = \beta a + \beta e\,(\ln PML/PDL)_t + \beta d(\ln Q)_t + (1-\beta)(\ln ML)_{t-1} + \beta u_t \qquad (45.2)$$

where β as before is the adjustment coefficient. The βb, βc, βd and βe are short run demand elasticities for log imports with respect to the price of imports, domestic price of hardwood logs, construction activity, and relative price of imports, respectively. It should be noted that the respective signs of their elasticity coefficients should be the same with the long run elasticity coefficients given in model 1 above.

Polynomial Distributed-Lag Import Demand Model

Model 3 - This model is based on the hypothesis that current demand for hardwood log imports is a function of the current and previous levels of construction activity and import price (see Table 4.1). Moreover, it presumes that the influences of the previous values of the explanatory variables can be approximated by distributed lag polynomial of order k and degree r (recall equations (30)-(32)). In the formulation of the estimable model a major problem is encountered because of the relatively short time series and the likelihood of losing considerable number of degrees of freedom as a consequence of calculating the distributed lag model. As it is known, as one increases the length of the lag the sample size is greatly reduced in the same proportion. That is, if the optimal lag length happens to be equal to four, the same number of sample observations will be omitted in the process of estimation. In an attempt to preserve some parsimony in the explanatory variables, the two submodels formulated in model 3 consist only of two explanatory variables which are deemed to have major effects on import demand for hardwood logs. It states that:

$$\ln ML_t = a + \sum_{k=0}^{K} b_k(\ln PML)_{t-k} + \sum_{k=0}^{K} c_k(\ln Q)_{t-k} + u_t \qquad (46)$$

where Σb and Σc are, respectively, the long run elasticities of import demand with respect to import price and construction activity. The signs of these elasticities should be equal to those in model 1 (submodel 1).

F. Estimation Procedures and Techniques

In time series analysis the most prevalent problems encountered are multicollinearity among explanatory variables and serial correlation which is characterized by disturbances that are not independent through time. The presence of multicollinearity makes it difficult to disentangle the separate influences of each independent variable in determining the level of imports and usually leads to a conclusion that is less accurate. There are a number of ways to detect and solve collinearity between the explanatory variables. The simplest method in detecting its existence is through the simple correlation coefficient matrix and a more sophisticated one is by calculating the variance inflation factors (VIFs).[149] These two methods are employed in this study. Since the first method can only identify pairwise correlations and not the entire interrelationships among the explanatory variables, the VIFs method serves to strengthen the inference obtained from the former. If the pairwise correlation is equal to or greater than 0.80, multicollinearity is said to exist. The VIFs are estimated by undertaking auxillary regressions which each regressor is in turn regressed on the other explanatory variables. That is, if X_i (i=1,...n) refers to the set of explanatory variables, the method proceeds by regressing X_1 on X_{n-1} and so on. The formula for estimating VIFs is given by

$$VIF(X_i) = TSS(X_i)[var(b_i)] / \sigma^2 \qquad (47)$$

where $TSS(X_i)$ is the total sum of squared residuals obtained in the regression of X_i on the rest of the X's; $var(b_i)$ is the variance estimator of X_i obtained from the original equation, that is the regression of the dependent variable on all X's; and σ^2 is the variance of the estimate of the original regression equation. A VIF that is greater than 10 indicates severe linear dependency and the X_i giving the highest VIF is deemed to cause the greatest multicollinearity in the model. The objection in the use of the two methods concerns the problem of finding linear dependencies among the X's when there are relatively large numbers of explanatory variables occuring in one model. Also, as already noted, omission of some explanatory variables as a result of the previous methods may make a model prone to specification bias. In order to account for possible specification error due to omitted variables, the models are developed sequentially. That is, one explanatory variable is introduced at a time in the theoretical model in order to determine the significance or predictive power of each variable while at the same time minimize specification bias. Preliminary analysis of the data indicated that multicollinearity is not a serious problem, and except in one case the rest of the pairwise correlations have shown no more than 0.78. Such value is regarded tolerable in view of the specification error which may arise in the discrimination process.

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[149] Neter, J., W. Wasserman and M. Kutner, *Applied Linear Regression Models*, (Illinois: Richard D. Irwin, Inc., 1983).

The existence of autocorrelation will not affect the consistency or unbiasedness of the ordinary least squares (OLS) regression estimators but it does affect the efficiency of the estimators and reduces the reliability of the statistical tests. There are three test statistics that can be used to determine the presence of serial correlation. For import demand models without lagged dependent variable as a regressor, the Durbin-Watson d-statistic is utilized.

The closer the value of d-statistic to 2 the less autocorrelation is deemed to be present and the larger its value (i.e., $d > 4-du$, where du is the upper limit of significance points in a given confidence level) the higher the negative serial correlation. On both sides of the zone of no autocorrelation there are inconclusive regions. In the present study, if the calculated d-statistic lies within the inconclusive range the model in question is tested for a first order autocorrelation AR(1) using the Cochrane-Orcutt iterative method. The iteration process is ran through the SHAZAM program set at 1 percent convergence criterion which is expected to yield consistent and asymptotically unbiased parameter estimates. The calculated d-statistic is tested at 1 percent significance level.

For import demand models containing a lagged dependent variable, such as the partial adjustment models, the statistical tests suggested by Durbin[150] are employed. His first test is called an h-test which is carried out by calculating the following formula :

$$h = z\sqrt{\frac{n}{1-n(\mathrm{var}\beta)}}$$

where $z = 1 - d/2$

d = the Durbin-Watson statistic

$\mathrm{var}\beta$ = the estimates of the variance of β, and

n = the sample size.

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[150] J. Durbin, "Testing for Serial Correlation in Least-Squares Regression when Some of the Regressors are Lagged Dependent Variables," *Econometrica*, 38(1970) : 410-421.

No serial correlation is associated with a value of $h < 1.645$ at the 5 percent level of significance. Recently, Johnston[151] and Spencer [152] point out the limitation of the h-test. It appears that the test breaks down whenever large sampling fluctuations occur which may cause $[n \bullet var\beta]$ to be greater than one. Durbin proposes an asymptotically equivalent test which is called, following Spencer, an m-test. This test is carried out as follows. First, the model wherein one of the regressors is the lagged value of the dependent variable is estimated by using the OLS, and the calculated residual u_t is obtained. The u_t is in turn regressed on the lagged residual u_{t-1} and the set of explanatory variables, and the coefficient of u_{t-1} is tested using the usual t-test. If its coefficient turns out to be not significantly different from zero, the null hypothesis of no serial correlation is accepted. The application of m-test thus becomes desirable whenever $[n \bullet var\beta] \geq 1$, otherwise the h-test is preferable since it only uses the regression results (statistics) of the original model and therefore minimizes computation costs.

Although OLS serves as an appropriate technique in estimating the parameters of the single equation, import demand models, it does not prove to be a desirable technique for the multivariate system equation model. Banskota (1984) gives some reasons on the latter point, and emphasizes the problem of removing multicollinearity entirely and losing some information emanating from the OLS to estimate only the cost function parameters. In the actual estimation of the multivariate equation system, the disturbance terms may not exhibit their stochastic properties and one is lead to expect that although their mean value is zero, the covariances between these disturbances (across equations) are nonzero. Zellner[153] has proposed a method, known as the seemingly unrelated regression equations, to deal with disturbances that exhibit zero mean but nonzero covariances. It proceeds by first deleting one share equation and then using the Generalized Least Squares (GLS) technique. The adding-up condition necessitates the dropping of one share equation, but Zellner's method is criticized because of the sensitivity of the parameter estimates to the one equation deleted. As a consequence, one may obtain sets of different parameter estimates which could not be diagnosed to find the set that provides the right estimators.

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[151] See J. Johnston, op. cit., p. 318.

[152] B.G. Spencer, "The Small Sample Bias of Durbin's Tests for Serial Correlation, When One of the Regressors is the Lagged Dependent Variable and the Null Hypothesis is True," *Journal of Econometrics* 3(1975) : 249-254. He found that the m-test detects the absence of serial correlatrion in the expected proportion of trials with greater reliability than the h-test.

The present study resorts to the method suggested by Kmenta and Gilbert,[154] which has been widely applied in current literature[155] and is known as the iterative Zellner-efficient (IZEF) estimation procedure. It is an iterative technique in which a convergence criterion is set at a more desirable level of accuracy that yield efficient estimates of the parameters equivalent to the maximum likelihood estimates so long as the estimates converged to the desired level. Normally the convergence criterion is set at one percent. This technique is desirable since the parameter estimates are not sensitive to the share equation dropped. Recalling in mind the gain in efficiency of the parameter estimates and the full information that can be obtained in using the full dual system (the translog cost function and the (n-1) cost share equations), this study uses the entire system.

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[153] A. Zellner, "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias,"*Journal of the American Statistical Association*, 57(1962) : 977-992.

[154] J. Kmenta and R.F. Gilbert, "Small Sample Properties of Alternative Estimators of Seemingly Unrelated Regressions,"*Journal of the American Statistical Association*, 63(1968) : 1180-1200.

The discussion so far has focused on estimation techniques and methods utilized to circumvent or avoid some of the serious problems inherent in the analysis of time series data in order to derive unbiased (or at least consistent) and efficient estimators of import demand elasticities. The next two subsections will discuss the procedures followed in testing different alternative technologies in the United States residential construction industry, and in choosing the appropriate lag length and degree of polynomial in the Almon distributed lag models respectively.

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[155] See for example E.R. Berndt and L.R. Christensen, "The Translog Cost Function and the Substitution of Equipment, Structures and Labor in US Manufacturing 1929-68," *Journal of Econometrics* 1(1973) : 81-114; and L.R. Christensen and M.E. Manser, "Estimating US Consumer Preferences for Meat with a Flexible Utility Function," *Journal of Econometrics* 5(1977) : 37-53.

Hypotheses Tests and Test Statistics: Alternative Production Technologies in the U.S. Residential Construction Industry

If homotheticity characterizes the production technology in the United States residential construction industry, the nonhomothetic translog model (Model 1) will yield estimates of the cost function and hardwood plywood demand elasticities that are biased and should therefore be modified in light of the most appropriate model. The search for an appropriate model can be systematically done in two ways, as proposed by Banskota (1984), either in increasing or decreasing order of restrictiveness.[156] In other words, one can carry out the hypotheses tests in sequential order by commencing either from the most general, unrestricted model (such as Model 1) or from the most restricted model (like that of Cobb-Douglas form). Whenever one begins the tests from the most unrestricted model, the procedure is said to be of an increasing order of restrictiveness. This was the procedure used by Rockel and Buongiorno (1982) in their study of inputs demand in the same industry of current interest in the United States. Following them this study takes Model 1 as the null hypothesis and is tested against other alternative models. The tests are conducted as follows. When Model 1 is rejected in favor of the alternative hypothesis of homotheticity, the latter becomes the null hypothesis in the next round of test. The hypothesis testing continues until the null hypothesis cannot be rejected and the corresponding model is chosen as the most appropriate model that best approximates the underlying technology. However, if the nonhomothetic model turns out to be significant and cannot be rejected when tested vis-a-vis homothetic model, then the hypothesis testing is completed. The alternative models considered in this study include the following :[5]

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[156] See K. Banskota, op. cit., pp. 44-46.

Model 2 - homotheticity and homogeneity
Model 3 - constant returns to scale
Model 4 - Hicks neutral technical change
Model 5 - Cobb-Douglas function

All these alternative models contain independent linear restrictions which would be imposed on the nonhomothetic model during the process of hypothesis testing. This implies that only Model 1 will be estimated to test for each of the alternative models with the necessary restrictions imposed. The test for homotheticity and homogeneity contains five independent restrictions and for constant returns to scale, one restiction. Hicks neutral technical change can be tested with four independent restrictions, while Cobb-Douglas model requires 21 independent restrictions. Since all the restrictions involved are linearly independent, the likelihood ratio (LR) test can be utilized in testing the above models and hence employed in this study. Although the reader is referred to Banskota (1984) for a concise but easily comprehensible review of the LR test, the basic equation is given as follows:

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[5] These models should not be confused with the other import demand models postulated for the United States since the former are just possible alternatives to Model 1.

$$LR = 2\ (\log LVU - \log LVR)$$

where LVU is the maximum value of the likelihood function for the model without restriction and LVR the maximum value of the likelihood function for the model subject to restriction. Under the null hypothesis this test statistic is (asymptotically) distributed as Chi-squared with number of degrees of freedom equivalent to the number of restrictions to be tested. The null hypothesis is accepted if LVR is less than LVU, which is equivalent to the value of the test statistic (LR) which is less than the appropriate critical value. The LR test requires the estimates of both the restricted and unrestricted models.

Choosing the Optimal Lag Length and Degree of Polynomial in the Almon Distributed Lag Models

In the previous chapter some approaches in the estimation of both the optimal lag length and degree of polynomial in the Almon model when no a priori information about them exist have been noted. Theoretically, there is no good justification underpinning the use of a given length of lag or degree of the approximating polynomial[158] and the question of choice thus becomes an empirical problem. To find an empirical solution that is desirable however, necessitates one to establish a basis grounded on some acceptable choice criteria. A sound criteria could be based on certain statistical tests.

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[158] J. Chou and J. Buongiorno, op. cit., p. 233.

In this study the approach to estimate the optimal value of k and r (recall equations (30)-(32)) is done in two stages. The first stage concentrates on the selection of the appropriate value of the lag length k. In most cases, only the model containing the import price and an activity variable (i.e., INP or Q) is examined for this purpose. The model is estimated with k set at 3, 4, 5 and 6 quarter lags consecutively and the particular lag that provides the highest $\bar{R}^2$ statistic and minimum standard error of the estimate is chosen. Preliminary results have indicated that the model containing the explanatory variables lagged four quarters gave the best fit and minimum standard error. One may be critical about the collinearity among the current and lagged values of the explanatory variables which may result in wrong inferences in choosing the optimal lag ength. Multicollinearity did not appear to be a serious problem in the conduct of the above inference procedure as none of the pairwise correlations exceeded 0.80. The second stage is directed to searching a suitable degree of the approximating polynomial. Given that the optimal value of lag length is four, it leaves this author few choices to obtain the suitable degree. This is so because the optimal degree of polynomial can, by definition, only be less than or equal to r, given that its degree is at most K which is equal to four. In other words, the value of the degree of the approximating polynomial cannot exceed the maximum (optimal) value of the length of lag. Thus, instead of carrying out an statistical test such as the one suggested by Johnston discussed earlier, each model is estimated using a polynomial lag structure of order k=4 and degree r=3 and 2; the estimation is equivalent to the problem of computing the parameters of a general linear model with necessary restrictions. The choice criteria in the first stage is likewise employed, but now includes a test for serial correlation. The estimation is done without "endpoint restrictions" to avoid "the unintended effect of predetermining the shape of the lag structrure."[159]

In practice some "endpoint restrictions" are imposed on the Almon distributed lag model. There are three types of "endpoint restrictions" and each is responsible for a particular shape of the lag distribution.[160] Firstly, one can constrain the lag distribution by imposing "both end restrictions" which results in a shape of the lag structure that increases for some quarters (or time lags) and then decreases after reaching a peak. This is equivalent to restricting the b and c in Model 3 (equation (46)) postulated for Japan (but also applies to other similar models formulated for South Korea and the United States) to $b_{-1} = 0$ and $b_{k+1} = 0$, and $c_{-1} = 0$ and $c_{k+1} = 0$ respectively. The other two types of restrictions involve the imposition of one near end-point constraint or one far end-point constraint. Maddala notes that imposing the $b_{-1} = 0$ and $c_{-1} = 0$ "may be overly strong in dictating the shape of the lag distribution in the initial stages;" however, the constraints $b_{k+1} = 0$ and $c_{k+1} = 0$ are "not (an) unreasonable (one) if one believes in a decaying lag distribution."[4] Thus imposition of the far end-point constraint will enable one to test whether the assumption embodied in partial adjustment model regarding lag distribution is acceptable. This study tests the validity of the one far end-point and both end-points constraints. The hypothesis testing is done by taking the unrestricted distributed lag model obtained in stage two above as the maintained null hypothesis, and the model subject to either of the two constraints of interest as the alternative hypothesis. The test procedure is not sequential in nature and thus both of the restrictions or only one of them can be accepted valid. Also, it is possible that none of the two end-point restrictions is applicable. The F-tests equivalent to the likelihood ratio test statistics, as suggested by Dhrymes (1981), are used in this part of the study. The test statistics have the form:

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[159] P.J. Dhrymes, *Distributed Lags: Problems of Estimation and Formulation*, (Amsterdam: North-Holland Publishing Co., 1981), p. 239.

[160] G.S. Maddala, *Econometrics*, (New York: McGraw-Hill Book Co., 1977), p. 358. The same reference provides a good discussion of the three types of "endpoint restrictions." One may also refer to P.J. Dhrymes (1981) and J. Johnston (1984).

$$\text{(i)} \qquad \frac{RSS1 - RSS0}{RSS0} \bullet \frac{T-k-r-1}{1} = F(1, T-k-r-1)$$

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[4] Ibid.

$$\text{(ii)} \quad \frac{RSS2 - RSS0}{RSS0} \bullet \frac{T-k-r-1}{2} = F(2, T-k-r-1)$$

where RSSO = the sum of the squared residuals of the no end-point constrained model,

RSS1 = the sum of the squared residuals corresponding to the one far end-point constrained model,

RSS2 = the sum of the squared residuals corresponding to the both end-points constrained model,

T = the sample size,

k = the length of the lag, and

r = the degree of the polynomial.

The null hypothesis of no end-point restriction is rejected if the computed F statistics exceed the critical value of F at a certain specified level of significance. The test is carried out at 5 percent confidence level. In (i) above, the F(1, T-k-r-1) is a central F-distributed stochastic variable with 1 and T-k-r-1 degrees of freedom, while in (ii) the F(2, T-k-r-1) is a central F-distributed random variable with 2 and T-k-r-1 degrees of freedom.

G. The Data

The purpose of this section is to present the sources of data utilized in this study, and the procedure for the transformation of raw data and reconstruction of index data. The diverse sources of information (data) and characteristics of the raw data necessitate their discussion on a per importing country basis. The use of quarterly data offers some advantages in the kind of analysis the present study intends to undertake. Firstly, the the influence of adjustment costs associated with stock adjustments and related concerns can be determined. Secondly, any seasonal effect on import demand can sufficiently be accounted for and examined. Moreover, the results based on this study can be used to forecast short- and medium-range trends in import demand.

The United States

Quarterly data covering the period 1967 to 1983 are collected from a variety of statistical reports including the *U.S. General Imports: Schedule A: Commodity by Country*, *Construction Review*, *Survey of Current Business* which are all published by the U.S. Department of Commerce, and the *Producer Prices and Price Indexes* circulated by the Department of Labor. Calculation of the import data is based on the seven-digit SITC statistics which include three major categories of hardwood plywood imports, namely: (1) "plywood, with a face ply of Philippine mahogany, bagtikan, red lauan, white lauan, etc.," (2) "plywood, with a face ply of mahogany," and (3) "plywood, with a face ply of spanish cedar and other hardwood."[162] The quantity of imports available every month are aggregated for each quarter, whereas the average import price is estimated in a two-level procedure. First, the ratio of imported hardwood plywood in category i (i=1,2,3) from the ASEAN member country j (j=1,...,5) at period t to the total imports of that category i is multiplied by the unit value of i from j for the same period. The sum of these gives the average import price of hardwood plywood in each category. The unit import value of hardwood plywood i from j is calculated as the ratio of total import value of i from j to its corresponding total volume in period t. To illustrate this, let :

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[162] For proper reference, see *U.S. General Imports: 'Schedule A: Commodity by Country.'*

PMP_{it} = the estimated average import price of hardwood plywood i (i=1,2,3) from the whole ASEAN countries in period t, (t=1,2,...,68),

PMP_{ijt} = the unit import value of i from j (j=1,2,...,5) at t,

MP_{it} = the total quantity of imports in category i at t,

MP_{ijt} = the quantity of imports in category i from j at t,

then the estimated average import price of i is :

$$PMP_{it} = \sum_{j=1}^{5} [PMP_{ij} \ (MP_{ij}/MP_{i})]_{t}.$$

In order to obtain the average import price for the three categories of hardwood plywood imports, the ratio of the quantity of imports in each category to the total quantity of the three categories is multiplied by the average price of hardwood plywood in the same category, and then summed. This can be written as:(6)

$$PMP_{t} = \sum_{i=1}^{3} [PMP_{i} \ (MP_{i}/MP)]_{t}$$

where

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(6)In a more concise formula, derivation of PMP_t is written as: $\Sigma_i^3 \ [(MP_{ij}/MP)] \ PMP_{ij}$.

PMP_t = the estimated average price of all hardwood plywood imports in period t, and

MP_t = the total quantity of all hardwood plywood imports.

In this study PMP is referred to as the weighted average price of hardwood plywood imports in view of the procedure used to derive it. It may be noted that not all imports of hardwood plywood are used by the residential construction industry and hence its cost share may be overestimated. The absence of any quantitative information regarding the proportion of imported hardwood plywood that are actually utilized by the industry however, results in the use of total imports. The total expenditure on imported hardwood plywood in each quarter is derived by multiplying its total volume (i.e., MP_t) with PMP_t. However, both PMP and MP are expressed in Divisia indixes, and which also hold true for the other factor inputs considered for inclusion in the import demand models postulated for the U.S. For South Korea and Japan, the index data provided in various publications are used as they are reported, as long as they are consistent with each other. Otherwise, a new series is constructed; the procedure for this is discussed below.

Data for the actual quantities of other factor inputs used in residential construction appear not to be readily available and, therefore, an indirect estimation becomes inevitable. For lumber input, the quantity of shipments of Douglas-fir lumber in the U.S. is assumed to be a good indicator. Douglas-fir lumber is chosen since it dominates other wood species in terms of lumber shipments in the sample period considered in this study. Thus, although lumber of other species takes a part in housing construction, their aggregate volumes are taken to be the same fraction of the quantity of Douglas-fir that have been shipped at the time but unused by the industry. Also, Douglas-fir seems to be the leading species for lumber and plywood production in the U.S. and, as well, for residential construction. Rockel and Buongiorno (1982), for instance, used the price of Douglas-fir lumber as a representative of the price of all softwood lumber in studying inputs demand in the residential construction industry in this country. The price of Douglas-fir lumber is available in the Department of Labor's *Producer Prices and Price Indexes*, and the Department of Commerce's *Survey of Current Business*. The quantity of softwood plywood produced each quarter in the U.S. is equated to the total domestic plywood volumes utilized by the industry. Supposedly, quantity shipments of (domestic) softwood plywood is preferable than the production data because some of the quantity produced are maintained as a component of the existing inventory of this intermediate input. Unfortunately such data were unavailable in the early portion of the sample period. *Construction Review*, for example, started recording the quantity of shipments of softwood plywood in 1981. The availability of plywood inventory can be subtracted from its quarterly production to obtain an estimate of quantity shipments, but this is not done to avoid any error that could result from the effect of extended inventory from the previous quarters. The data for the price of softwood plywood are obtained from the same documents already cited.

The average number of special trade construction workers employed in a month are used as indicator of the labor input. Special trade construction workers include those who are involved in plumbing, heating and air conditioning; painting, paperchanging and decorating; roofing and sheet metal work; electrical work; etc. [164] Their corresponding average weekly earnings are taken from *Construction Review* (Table G4) and serve as a measure of the price of labor.

Quantity and price of capital required in residential construction are the most difficult data to obtain.It is presumably the reason why Rockel and Buongiorno (1982) did not include the price of capital in their study. In contrast to the two authors however, this study regards capital cost as an important component of total cost for building a residential unit. Since the actual capital-stock data for the industry are unavailable, this study takes a very stringent assumption that the quarterly average of new mortgage loans extended by all Savings and Loan Associations in the U.S. for home construction purposes can reflect that of the industry's capital input. This assumption seems implausible considering the fact that some of the loans flow directly to individual households, and this would mean that part of the costs attributed to capital services in the industry are borne by the final consumers. Consequently, it tends to affect the derived demand approach that is applied here. In view of this, care must be made in interpreting the results of the models where such variable is incorporated. A simple approach to measuring the price of capital is to estimate the rate of return to capital in the industry; an approach used by Nautiyal and Singh (1983). For the present purpose, and to be consistent with the quantity of capital to be used, the quarterly average of home mortgage rates (conventional first mortgages) is utilized as an estimate of the price of capital. *Survey of Current Business* reports both the averages of new mortgage loans and of home mortgage rates.

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[164] For a complete description of special trade construction workers, see U.S. Department of Commerce, *Construction Review*; this document is published monthly.

The cost of each input is calculated as the product of its price and quantity. The estimation of the translog model requires the conversion of input prices and quantities into indexes. The indexes of input prices and quantities are calculated using the Divisia indexing procedure.[145] The use of indexes helps mitigate the effects of units of measurement of the various inputs on the parameter estimates of the different models.

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[145] For details of the Divisia indexing procedure, see W.E. Diewert, "Exact and Superlative Index Numbers," *Journal of Econometrics* 4(1976): 115-146; and "Superlative Index Numbers and Consistency in Aggregation," *Econometrica* (1978): 883-900.

In the single equation import demand models the price of other construction materials appears occassionally. An aggregate Divisia price index of fabricated structural steel and portland cement is calculated and used as an indicator of the price of non-wood factor inputs in residential construction. In model 1, the total cost is estimated as the sum of expenditures spent on each input. The Boeckh index of building costs for residences however, can also be used to represent the total cost of residential construction in the U.S., as done be Rockel and Buongiorno (1982). This particular cost index is not tried in the present study because, as Swan has found, "it tends to overstate the 'true' increase in construction costs."[166] In addition, its use will not permit the derivation of the required cost share equations due to the composition of that cost index which far exceed the number of factor inputs considered in this study. Also, capital cost is excluded from the Boeckh cost index.

The total number of new housing units started in each quarter is considered as the output variable which appear as an argument of the cost function.

South Korea

The two major sources of quarterly data for the variables included in the models for South Korea are the *Monthly Foreign Trade Statistics* published by the Office of

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[166] C. Swan, "Labor and Material Requirements for Housing," *Brookings Papers on Economic Activity*, 2(1971), p. 348.

Customs Administration, and the *Monthly Bulletin of Statistics* by the United Nations Department of International Economic and Social Affairs. The period of study for this country covers nine years, or 36 quarterly observations, starting in 1970. Data for the quantity and price of hardwood log imports are calculated in exactly the same procedure as that of the United States'. In particular the log imports considered here fall under two commodity classifications based on the classification standards established by the Office of Customs Administration. These are (1) lauan sawlogs and veneer logs, and (2) sawlogs and veneer logs of wood grown in the tropics (n.e.s.).[46] The data for industrial production index pertaining primarily to manufacturing industries are taken from the *Monthly Bulletin of Statistics* and consistent with the U.N. Internationsl Standard Industrial Classification (ISIC) of All Economic Activities. This index is used as an indicator of production activity in the forest products industry. The same document provides data on general wholesale price index which are utilized to represent the price of other intermediate inputs. This index refers to a representative list of commodities priced at the wholesale stage of distribution and may represent the prices paid by the importers to producers (exporters), manufacturers to wholesalers, etc. The variable depicting construction activity in the United States is basically the output variable used in this country.

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[46] It may be noted that their specific commodity codes have changed over time.

Japan

The data for the variables which appear in the models postulated for Japan are taken in the following publications: Japan Tariff Association's *Japan Exports and Imports: Commodity by Country*, Economic Commission for Europe and F.A.O. of the United Nations' *Monthly Prices for Forest Products*, and *Monthly Bulletin of Statistics*. Also some valuable statistics are supplied by Dr. Isamu Nomura of the College of Agriculture and Veterinary Medicine, Nihon University.

As noted earlier, this study focuses on the current import demand for hardwood logs in Japan and covers only 20 quarterly observations beginning first quarter of 1979. The import data are estimated from seven-digit Commodity Classification for Foreign Trade Statistics. The procedure used to calculate the weighted average import price and quantity of imports in the United States is also applied here. The import price is based upon the cost, insurance, and freight (c.i.f.) value, as in the case of South Korea. The residential construction activity or output variable is measured by the number of new dwellings constructed in each quarter, wherein the latter are defined as containing rooms or suite rooms suitable for occupancy by one family. *Monthly Prices for Forest Products* reports the average price of lauan logs (60 cm. diameter and 4 m. length) in Tokyo. This is used as the domestic price of hardwood logs imported in

Japan. The category of log imports considered in this study refers to imported sawlogs and veneer logs of lauan, keruing, mersawa and other species of the Dipterocarpaceae family (44.03-331).

Some index data need reconstruction because of the periodic changes in base year. Ho's [168] procedure for estimating optimal reconstructed index data is employed in the present study to avoid any inconsistency resulting from the use of incompatible sets of aforementioned data. His procedure is relatively simple and essentially involves linear regression. For as long as there are no changes in categorization of data and the weights, the new index data can be calculated by using two overlapping inconsistent series (i.e., with different base years for the same period) and regressing one set of index data with the desired base year on another. The estimated coefficient of the other set of index data is then multiplied by the remaining series belonging to it to obtain a complete series of index data of the preferred set. This procedure is equivalent to finding the ratio between any pair of the overlapping observations which are not on the same base.[169]

The results of the estimation of the various import demand models and hypotheses tests will be discussed in the next chapter.

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[168] D.S. Ho, "The Reconstruction of Index Data in Aggregative Econometric Models," *Journal of Econometrics* 10(1979): 333-359.

[169] For the second procedure, see R.D. Mason, *Statistical Techniques in Business and Economics* (Illinois, Richard D. Irwin, Inc., 1982), pp. 152-154.

V. EMPIRICAL RESULTS FOR THE IMPORT DEMAND MODELS

A. Introduction

The empirical estimation of the several import demand models using appropriate data sets discussed in the previous chapter fulfills three of the primary objectives of this study presented in the first chapter. Firstly, the results of the empirical estimation provide a means to examine statistically the factors influencing the demand for the ASEAN hardwood log imports in Japan and South Korea, and hardwood plywood imports in the United States in the more recent decade or so. Secondly, the same results give estimates of the import demand elasticities with respect to the relevant factors affecting demand which are vital inputs in the formulation of trade and related policies and in forecasting purposes. Similarly, an analysis of the parameter estimates of the dynamic models that provide a mechanism to capture any adjustment pattern in import demand can further improve the basis for planning and policy making. Finally, the complementarity-substitution relationships between imports (of hardwood logs or plywood) and other factor inputs can be determined quantitatively. The latter, however, is more discernible in the case of hardwood plywood imports in the United States wherein its demand in the residential construction industry is decided along with other inputs, and thus its relation with domestic inputs can readily be ascertained from the partial elasticities of substitution. In the case of Japan and South Korea, the relationships of hardwood log imports to other factor inputs could be examined only indirectly through the impact of the prices of other inputs on the level of import demand.

In the succeeding sections the empirical results for the import demand models by importing country are discussed. Towards the end of the chapter some comparisons of the performance of the different models is made to carry out the secondary objective of the present study. However, it should be noted that a valid comparison of the models requires one to use at least a similar estimation technique. For the single equation import demand models this requirement is satisfied as OLS serves as the main estimation technique, although a detection of serial correlation necessitates the reestimation of the parameters of the model (or submodel) in question using the first-order Cochrane-Orcutt iterative technique. The use of the iterative Zellner-efficient (IZEF) estimation technique for model 1 of the United States, which consists of a multivariate system of equations, appears to yield estimates not directly comparable with the other models postulated for this country. For one thing, single equation demand models may be prone to simultaneity bias in demand. Furthermore, comparison of the empirical performance of the single equation static, partial adjustment and polynomial distributed lag models should be carried out with proper recognition of the embodied maintained hypothesis (or a priori restrictions on the parameters) and computational problems in each model. The next section presents the results of the estimation of the models formulated for the United States.

B. The United States

Results of the empirical estimation of the four models postulated for the United States are discussed separately under three subsections. The first subsection focuses on the two static import demand models (models 1 and 2), while the partial adjustment (model 3) and polynomial distributed lag (model 4) models are treated in the subsequent subsections. This section contains only the results of demand and substitution elasticities. Biased technical change in input use that may have existed in the residential construction industry over time, as a result of model 1 estimation, is examined in Appendix B.

Static Import Demand Models

Model 1 - As has been noted earlier, the nonhomothetic model initially postulated for the residential construction industry may be changed subject to the outcome of the hypotheses testing. The alternative models enumerated in Chapter 4 and discussed in Chapter 3 are calculated along with the nonhomothetic model, and then the likelihood ratio (LR) test is carried out to determine the most appropriate model that best approximates the production technology underlying the industry. The estimated parameters of the chosen model are used to calculate the own- and cross-price factor demand elasticities and partial elasticities of substitution. With the procedure of the hypotheses tests adopted in this study it has been found that Cobb-Douglas is inappropriate as a representation of the technology in this industry.

Tables 5.1 and 5.2 present the estimated coefficients and t-ratios of the different translog models. An examination of the parameter coefficients of the nonhomothetic model (model 1) implies that three of the four homotheticity parameters are significantly different from zero. On the other hand, both the homogeneity and constant returns to scale parameters are insignificant. All the coefficients of the biased technical change parameters appear to be highly significant. However, the significance of these parameters based on t-values does not actually indicate the most appropriate model, but simply implies that the parameters are significantly different from zero at the one or five percent confidence level. To determine the best approximating model of the U.S. residential construction industry's production technology, an LR test is performed in which the nonhomothetic model is the null hypothesis and tested against the different alternative hypotheses. The results of the LR test are given in Table 5.3. The computed X^2 values infer that model 3 which is characterized by homotheticity, homogeneity and constant returns to scale

Table 5.1 Estimated Coefficients of Different Translog Cost Functions: U.S. Residential Construction, 1967-I-1983 IV

	Model 1	Model 2	Model 3	Model 4
γ_o	-2.259	1.681*	1.686*	1.797*
γ_y	1.101	1.001		
γ_{yy}	-.143			
γ_t	-.022*	-.027*	-.027*	-.037*
γ_{tt}	-.000*	-.000*	-.000*	-.000
γ_L	-.154	-.255**	-.254**	-.514*
γ_K	-.521*	-.416*	-.416*	.186**
γ_{MP}	-.071	.115	.115	-.131
γ_{DP}	-.036	-.043*	-.143*	-.029*
γ_{LL}	.035**	.029	.029	.117*
γ_{LK}	.001	.015	.015	-.121*
γ_{LMP}	-.026*	-.013	-.013	.032*
γ_{LDP}	-.992*	-.522**	-.520**	-.624*
γ_{KK}	-.084**	-.113*	-.113*	.372*
γ_{KMP}	.099*	.067*	.067*	-.097*
γ_{KDP}	-.055*	-.029	-.029	-.100*
γ_{MPMP}	.023	.000	.000	.052
γ_{MPDP}	-.073*	-.048*	-.048*	-.022
γ_{DPDP}	.028*	.208*	.208*	.179*
γ_{Ly}	-.023*			
γ_{Ky}	.039			
γ_{MPy}	.053**			
γ_{DPy}	-.043*			
γ_{L_t}	-.002*	-.002*	-.002*	
γ_{K_t}	.009*	.009*	.009*	
γ_{MP_t}	-.003*	-.003*	-.003*	
γ_{DP_t}	-.001*	-.001*	-.001*	
γ_{Q_t}	.008*	.009*	.009*	.009*
$\bar{R}^2$	.91	.88	.88	.86
LLV	772.20	763.21	763.21	681.43

Notes: Model 1 = Nonhomothetic function
2 = Homothetic and homogeneous function
3 = Constant returns to scale
4 = Hicks neutral technical change

The * and ** refer to significance at 1 and 5 percent confidence levels respectively.

Table 5.2 t - Ratios of Estimated Coefficients of Different Translog Cost Functions: U.S. Residential Construction, 1967 I - 1983 IV

	Model 1	Model 2	Model 3	Model 4
γ_o	1.155	12.707	37.460	47.422
γ_y	1.690	1.100	-	-
γ_{yy}	1.307	-	-	-
γ_t	2.993	4.083	6.586	10.078
γ_{tt}	4.801	5.049	5.108	1.500
γ_L	1.291	2.245	2.259	5.015
γ_K	3.446	3.988	3.993	2.110
γ_{MP}	0.592	1.413	1.412	1.689
γ_{DP}	3.893	4.851	4.851	3.154
γ_{LL}	2.298	1.927	1.927	13.233
γ_{LK}	0.694	1.287	1.286	10.591
γ_{LMP}	3.258	1.685	1.686	3.813
γ_{LDP}	3.771	2.110	2.102	2.901
γ_{KK}	2.112	3.236	3.235	6.850
γ_{KMP}	3.825	2.690	2.691	3.595
γ_{KDP}	2.893	1.693	1.694	7.071
γ_{MPMP}	0.709	0.004	0.004	1.564
γ_{MPDP}	4.857	3.262	3.263	1.553
γ_{DPDP}	11.954	11.275	11.278	9.814
γ_{Ly}	3.793	-	-	-
γ_{Ky}	1.531	-	-	-
γ_{MPy}	2.543	-	-	-
γ_{DPy}	3.453	-	-	-
γ_{Lt}	13.337	13.724	13.742	-
γ_{Kt}	17.309	18.387	18.414	-
γ_{MPt}	9.324	8.458	8.466	-
γ_{DPt}	4.432	5.070	5.086	-
γ_{Qt}	6.096	7.489	12.660	13.502

Note: Critical values with 289 degrees of freedom are t(.05) = 1.960 and t(.01) = 2.576. Notice that these critical values of t correspond for infinite number of degrees of freedom. The number of degrees of freedom is computed following the procedure of Banskofa (1985) and Johnston (1984).

Table 5.3 Test Statistics for Model Selection:
U.S. Residential Construction,
1967 I - 1983 IV

Models	No. of Restrictions	X^2 (1 percent)	X^2 (5 percent)	Calculated X^2
2	5	15.09	11.07	8.99
3	1	6.63	3.84	0.00
4	4	13.28	9.49	163.56

Notes: The models refer to the following:
Model 2 to homotheticity and homogeneity
Model 3 to constant returns to scale
Model 4 to Hicks neutral technical change

cannot be rejected both at the one and five percent levels of significance. Therefore, the best approximating translog model (model 3) characterizes a homothetic and homogeneous production technology for the industry which exhibits constant returns to scale. In addition, this model indicates that the technology displays a nonneutral technical change. The rejection of model 4 makes estimation and testing of the Cobb-Douglas model (model 5) unnecessary as it embodies Hicks neutrality as a maintained hypothesis among others.

In terms of derived demand for hardwood plywood imports and other inputs, model 3 provides several relevant inferences which are worthy of note. First, the ratio of any two derived demand equations is not affected by changes in the level of output, and demand for a given input is only constrained by its price relative to the other input prices. Second, the existence of constant returns to scale in the industry implies that the derived demand for inputs will increase in proportion with output. In other words, the industry can double its output by doubling all inputs. Third, the technology underlying the industry exhibits biased technical change in input use. Over time this change has been biased against imported hardwood plywood, domestic plywood, domestic lumber and labor. In contrast, the technical change appears to be capital-using (see Appendix B). Finally, input substitution (complementarity) seems to be significant between primary factors and intermediate inputs as well as among themselves. Continuous improvement in the production (construction) technique, and design and stress properties of the intermediate inputs combined with changes in relative prices of inputs are the main reasons for the seemingly strong factor substitution.

Model 3 has a high percentage of the parameters which are significantly different from zero and a relatively high coefficient of determination adjusted for degrees of freedom. The computed Durbin-Watson statistic for model 3 lies in the uncertain range; the same is true for models 1 and 2 but there appears some positive autocorrelation in model 4.

The estimated parameters for model 3 are then used to compute own- and cross-price factor demand elasticities and substitution elasticities at each quarter and at the sample means for the 17 year-period. Table 5.4 gives the own- and cross-price factor demand elasticities computed at the sample means. The significance of the elasticity estimates can be determined from their corresponding standard errors. Except for the cross-price elasticity of demand for hardwood plywood imports with respect to the price of labor, all the estimated elasticities are twice greater than their standard errors. Similarly, all own-price demand elasticities for inputs except domestic plywood have the expected sign and are inelastic. It shoud be noted that the emphasis of the succeeding discussion is on the demand for hardwood plywood imports and the other inputs are therefore mentioned only whenever they are compared to the input of interest.

Table 5.4 Own and Cross Price Factor Demand Elasticities for the Translog Model , U.S. Residential Construction, 1967 I - 1983 IV

Input \ P_i	LABOR	CAPITAL	IMPORTED PLYWOOD	DOMESTIC PLYWOOD	DOMESTIC LUMBER
LABOR	-.570 (.132)	.653 (.104)	-.026 (.068)	-.304 (.077)	.247
CAPITAL	.151 (.025)	-.786 (.072)	.279 (.051)	-.526 (.035)	.263
IMPORTED PLYWOOD	-.096 (.066)	1.558 (.216)	-.880 (.271)	-.604 (.125)	.022
DOMESTIC PLYWOOD	-.182 (.055)	-1.498 (.105)	-.215 (.091)	.605 (.114)	-.827
DOMESTIC LUMBER	.243	1.144	.049	-1.358	-.078

The estimated elasticities are based on the sample means. The standard errors in parentheses are calculated by: $SE(\gamma_{ij}) = SE(\gamma_{ij})/S_i$. Each element in the column measures the change in the demand for input i (i = K, L. MP, DP, LU) resulting from the change in the price of input j ($i \neq j$) when all other input prices and the level of output are constant. Pi refers to the price of input i.

The own-price demand elasticities reported in Table 5.4 indicate that the demand for hardwood plywood imports is less inelastic compared with other factor inputs (except perhaps with domestic plywood with the unexpected sign on its elasticity coefficient) in residential construction. Its own-price demand elasticity estimated at the sample means is -.880. In comparison, domestic lumber demand appears to be very price inelastic, followed by labor and capital inputs. The positive own-price elasticity of demand for domestic (softwood) plywood is quite unexpected. Nevertheless, it can be attributed to the relative importance of domestic plywood in residential construction. In fact between 1965 and 1978, except the recession years of 1974-75, domestic softwood plywood consumption in the United States has expanded rapidly at an annual average of 3.5 percent and became almost equal to the domestic production in that period.[170] It appears that domestic plywood has become a basic input in the construction activity of the industry. An implication of this to the elasticity estimate for domestic plywood is that its price has little influence in determining its demand. Obviously, not all of the domestic plywood consumed in this country went through the construction of new housing but its share has remained the highest among the major uses of this input.

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[170] D.B. McKeever and G.W. Meyer, *The Softwood Plywood Industry in the United States, 1965-82*, Res. Bull. FPL 13, Madison, WI. U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, 1983, p. 5.

Over the years from 1967 to 1983 the values of the own-price demand elasticities of all factor inputs display remarkable trends. Estimates of these elasticities for selected years are reported in Table 5.5. The own-price elasticity of demand for imported hardwood plywood has increased gradually, but this change seems to reflect the impact of the oil crisis in the mid-seventies on the prices of all commodities traded internationally. This is evident in the sudden increase in absolute value of the demand elasticity for hardwood plywood imports in the third quarter of 1974. Therefore, the estimated mean elasticity of demand for imported hardwood plywood provides a better measure of the responsiveness of its demand to a change in its price in the more recent decade. In contrast, labor and capital demand have become more inelastic over the sample period although the change has been slightly less in labor than capital. Domestic lumber demand also tends to be more inelastic up to 1982 but surprisingly its elasticity turns positive in 1983. This positive demand elasticity for domestic lumber may reflect the time when the demand for housing has been revived after the trough period of 1979-82 in the business cycle. Also, prices of most inputs in residential construction have shown a declining trend over this period.

Table 5.4 likewise reports the cross-price factor demand elasticities estimated at the sample means. As noted below the table, each element in the column measures the

Table 5.5 Own-Price Demand Elasticities of Hardwood Plywood Imports and Other Inputs, Selected Years: U.S. Residential Construction, 1967 I - 1983 IV

		LABOR	CAPITAL	IMPORTED PLYWOOD	DOMESTIC PLYWOOD	DOMESTIC LUMBER
1967	1	-.655	-1.366	-.799	.241	-.440
	2	-.657	-1.133	-.824	.389	-.426
	3	-.658	-1.137	-.780	.795	-.439
	4	-.658	-1.209	-.744	.417	-.409
1973	1	-.649	- .983	-.846	.110	-.309
	2	-.641	- .933	-.830	.176	-.273
	3	-.653	- .919	-.838	.448	-.384
	4	-.657	-1.094	-.844	.158	-.417
1974	1	-.654	-1.026	-.831	.211	-.385
	2	-.649	- .834	-.887	.277	-.324
	3	-.658	-1.080	-.962	.029	-.459
	4	-.658	- .886	-.970	.208	-.447
1979	1	-.535	- .561	-.933	.459	-.010
	2	-.467	- .477	-.929	.959	.126
	3	-.467	- .478	-.939	.952	-.009
	4	-.501	- .501	- .937	.920	-.090
1983	1	-.374	- .420	-.932	1.325	.349
	2	-.282	- .397	-.912	1.972	.644
	3	-.163	- .442	-.867	2.124	.571
	4	-.148	- .458	-.850	2.242	.577

change in the demand for input i resulting from the change in the price of input j ($i \neq j$ to exclude the main diagonal elements) when all other input prices and the level of output remain unchanged. As mentioned in Chapter 3, the cross-price factor demand elasticities have a similar interpretation as the partial elasticities of substitution. Banskota (1984) shows that the former are proportional to the latter as given by the following relationship : $\eta_{ij} = \sigma_{ij}S_j$. Note that the cross elasticities of demand are not symmetrical as are the partial elasticities of substitution. These two types of elasticities will be positive for any pair of factor inputs that are substitutes and negative for complements. The fact that cross-price demand elasticities usually reflect the share of an input which the substitution elasticities do not (Binswanger, 1974), makes it reliable to evaluate the substitution-complementarity relationships between imported hardwood plywood and other inputs by utilizing the latter type of elasticities. This does not mean however, that the cross elasticities of demand for inputs are not worthy of notice and to provide a general trend of these elasticities over the years covered by this study, a sample is reported in Table 5.6.

In Table 5.7 a summary of the relationships of hardwood plywood imports with other inputs is presented. One may easily recognize the symmetry that exists in the estimated partial elasticities of substitution between inputs and the significance of these elasticities which are all twice

Table 5.6 Cross-Price Demand Elasticities of Hardwood Plywood Imports with Other Inputs, Selected Years: U.S. Residential Construction, 1967 I - 1983 IV

		LABOR	CAPITAL	DOMESTIC PLYWOOD	DOMESTIC PLYWOOD
1967	1	.134	.536	-.040	.169
	2	.116	.661	-.104	.150
	3	.122	.581	-.094	.171
	4	.107	.511	-.022	.148
1973	1	.048	.785	-.074	.088
	2	.048	.768	-.066	.082
	3	.059	.797	-.136	.119
	4	.066	.727	-.088	.138
1974	1	.065	.724	-.078	.121
	2	.016	1.032	-.238	.077
	3	-3.380	18.477	-12.702	-1.433
	4	-.374	3.108	-1.726	-.038
1979	1	-.128	1.655	-.578	-.016
	2	-.128	1.655	-.578	-.021
	3	-.161	1.824	-.700	-.025
	4	-.147	1.766	-.669	-.013
1983	1	-.148	1.747	-.630	-.037
	2	-.109	1.529	-.482	-.262
	3	-.063	1.224	-.295	.061
	4	-.053	1.155	-.257	.006

Table 5.7 Partial Elasticities of Substitution[1]: U.S. Residential Construction, 1967 I - 1983 IV

	LABOR	CAPITAL	IMPORTED PLYWOOD	DOMESTIC PLYWOOD	DOMESTIC LUMBER
LABOR	-5.544 (1.151)	1.336 (.215)	-1.179 (.581)	-2.792 (.478)	2.567
CAPITAL		-2.168 (.148)	3.498 (.437)	-3.303 (.215)	2.518
IMPORTED PLYWOOD			-14.778 (2.303)	-3.848 (.776)	.084
DOMESTIC PLYWOOD				5.457 (.709)	-10.003
DOMESTIC LUMBER					6.557

[1] These substitution elasticities are calculated at the sample means and their corresponding standard errors in parentheses are obtained by: $SE(\gamma ij) = SE(\gamma ij)/SiSj$.

greater than their corresponding standard errors. The results given in Table 5.7 are substitution elasticities computed at the sample means and apparently indicate that imported hardwood plywood is a strong complement of domestic plywood and labor, and a substitute of domestic lumber and capital. Simply, demand for hardwood plywood imports can therefore be expected to increase as more quantities of domestic plywood and labor are used in residential construction. However, a rise in demand for domestic lumber and capital may cause a negative impact on hardwood plywood imports. Although the mean values of the substitution elasticities can already provide indications of the relation of imported hardwood imports with other inputs, they may not at all times reveal the strengths of the substitution-complementarity relationships or the trend of these relationships that may have occurred over the years. More meaningful information can be gathered if one evaluates the trend over the years 1974-75 which seemed to mark the beginning of the dramatic changes in factor substitution.

The complementarity that exists between imported hardwood plywood and domestic plywood has increased considerably beginning the third quarter of 1974, and this relationship seems to have remained consistent from 1967 to 1983 with the exception of the first quarter in 1969. The latter period in which the two inputs appeared to be substitutes actually coincided with the sudden decline of the price of domestic plywood after having posted a record high in 1968. At the same time the price of hardwood plywood imports increased slightly. These changes in their relative prices could have been the source of the substitution relationship between the two inputs. On the other hand, their complementarity can be due to a number of reasons. One of these is the recent development in production of (domestic) softwood plywood, such as composite plywood, which enables it to be used for roof sheathing, single-layer floors and subflooring.[171] The expanded use of domestic plywood in residential construction may have served to increase the demand for hardwood plywood imports and thereby strengthen the complementarity between the two inputs. Hardwood plywood imports are utilized for interior decorative wall panelling. The fact that the two inputs are of different species and hence physical characteristics also render them to be good complements. This reasoning is consistent with the findings of Doran and Williams (1982) between imported and domestic sawn timber in the Australian residential construction industry, and the observation of Chou and Buongiorno (1982) that the two inputs under consideration have different applications in the United States. It is quite interesting to note that the mean value of the elasticity estimates indicating the complementarity of hardwood plywood imports with domestic plywood represents more closely the most recent trend of their relationship.

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[171] J.D. McNatt, W.L. Galligan and G.E. Hans, "Forest Products for Building Construction," *Wood and Fiber Science*, 16(1984): 180-213.

This means that this value can be used for forecasting purposes.

The mean elasticity estimate of complementarity between hardwood plywood imports and labor (i.e., -1.179) may not be a good reflection of their relationship over the entire sample period. Table 5.8 reveals that the two inputs have been substitutes from 1967 until the second quarter of 1974 and then eventually became complements. The substitution relationship that has prevailed in the first seven-and-a-half years may reflect the period when the general labor market has been tight due to the strength of demand from both residential and nonresidential construction in this country. Swan has earlier observed that "homebuilders have traditionally stood at the end of the manpower line. The supply of labor to construction is quite sensitive to aggregate labor market conditions and the supply of skilled labor to homebuilders is sensitive to the availability of other construction work."[172] In view of this, one can reasonably speculate that for the residential construction industry to attract its needed labor force necessitates the provision of higher wages and other fringe benefits, perhaps at the expense of other inputs such as hardwood plywood imports. The low own-price demand elasticity of labor (-.570) may limit its substitution by imported hardwood plywood which has nearly unitary own-price demand elasticity. The mean value of the elasticity for the

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[172] C. Swan, op. cit., p. 357.

Table 5.8 Substitution Elasticities of Hardwood Plywood Imports with Other Inputs, Selected Years: U.S. Residential Construction 1967 I - 1983 IV

		LABOR	CAPITAL	DOMESTIC PLYWOOD	DOMESTIC LUMBER
1967	1	.670	2.681	-.200	.845
	2	.607	2.390	-.606	.810
	3	.700	2.113	-.754	.859
	4	.675	2.064	-.130	.859
1973	1	.359	2.272	-.312	.685
	2	.370	2.069	-.305	.692
	3	.418	2.100	-.841	.756
	4	.438	2.484	-.393	.776
1974	1	.452	2.239	-.381	.767
	2	.119	2.403	-1.243	.583
	3	-18.450	61.779	-45.857	-6.045
	4	-2.380	7.798	-8.285	-.179
1979	1	-1.721	2.665	-3.606	-.200
	2	-2.079	2.406	-5.125	-.304
	3	-2.617	2.656	-6.171	.321
	4	-2.193	2.643	-5.798	-.151
1983	1	-2.934	2.379	-6.752	-.669
	2	-2.531	2.030	-6.715	-.581
	3	-1.746	1.710	-4.326	.013
	4	-1.487	1.643	-3.924	.119

two inputs therefore misrepresents the earlier period of observation in which they have been substitutes. On the contrary, that value reflects more the complementarity relationships that exists between hardwood plywood imports and labor (see Tables 5.7 and 5.8) in the more recent years. The change in their relationship can be due to the fast increase in the price of most inputs in residential construction, especially that of labor, capital , domestic lumber and domestic plywood. Although some reports would claim that the price of hardwood plywood imports has increased in the latter part of 1974 and beyond due to the unprecedented rise in the price of energy, the fact remains that its price in 1974-75 was only slightly higher than its price in the first quarter of 1967. It may well be that the industry has responded to the changes in input prices and thus imported hardwood plywood became a complement of labor. The period-by-period elasticities of substitution tend to imply that hardwood plywood imports and domestic plywood may have been used to substitute for domestic lumber; though the latter appears to be a complement of domestic plywood which is contrary to the findings reported by Rockel and Buongiorno (1982) and Mills and Manthy (1974). However, McKillop and others (1980) have failed to find significant correlation between domestic lumber and domestic plywood. Unfortunately, the results obtained in this study about the relationship between imported hardwood plywood and other inputs in residential construction cannot be compared directly with the previous findings as this imported input has not been considered earlier, with the exception of Chou and Buongiorno (1982, 1983) reviewed in Chapter 3. The results reported in Table 5.7 imply that a rise in demand for hardwood plywood imports takes place as the demand for labor increases.

Imported hardwood plywood and domestic lumber have been substitutes in most of the period considered, although it has declined over time. In 26 of the 68 quarters covered by this study, however, the two inputs behaved as complements. This complementarity has probably occurred due to the rapid rise in price of domestic plywood which has been found to serve as a complement for domestic lumber and hence encouraged the industry to use hardwood plywood imports in some parts of the residential units previously made using domestic plywood. This complementary relationship, on the other hand, seems to be impermanent and a consequence primarily of the changes in factor prices. The substitution between imported hardwood plywood and domestic lumber may reflect their similar applications in residential construction. Rapid developments in the lumber industry in the United States made it possible to convert solid-sawn structural lumber into such related products as stressed-skin panels which compete with some panel products, including the imported input. The results in Table 5.8 also indicate that the decline in the degree of substitution between the two inputs has been substantial over the years, but the mean substitution elasticity appears to be good enough to represent their relationship in the last two years of the sample observation.

The imported hardwood plywood exhibits a substitution relationship with capital that tends to increase gradually from 1967 to 1978 and stabilizes in the remaining years. During the entire period of observation however, the substitution relationship remains fairly strong. Considering the variables used to represent the price and quantity of the capital input in residential construction, caution should be made in interpreting this relationship. Nevertheless, one can attribute the strong substitution between the two inputs to technical change which has been factor-using for capital input and factor-saving for hardwood plywood imports. This may indicate that the use of more improved capital-intensive equipment in residential construction has made it possible to reduce the use of the imported input.

In spite of the sharp changes in the partial elasticities of substitution between imported hardwood plywood and other inputs between 1974 (third quarter) and 1983, the mean values of these elasticities reported in Table 5.4 still proved to be applicable for the purpose of forecasting future demand for hardwood plywood imports as they reveal more of the recent trend in factor substitution or complementarity.

Model 2 - The resulting estimates of demand elasticities for hardwood plywood imports of the six submodels comprising model 2 appear in Table 5.9. The elasticities of demand for imported hardwood plywood with respect to the input prices and other relevant variables are estimated at the sample means. As expected, the demand elasticity of hardwood plywood imports with respect to its price bears a negative sign, indicating their inverse relationship. In submodel 1, this elasticity is -.994 and significantly different from zero at the five percent confidence level. The same submodel indicates that the demand for the imported input will increase by 5.03 percent for every ten percent rise in residential construction activity (i.e., output level) when all other factors are held constant. The positive import demand elasticity attributed to the output variable is likewise statistically significant (at the one percent level). In terms of goodness of fit, submodel 1 tends to be at par with other submodels, as evidenced from the coefficient of determination corrected for degrees of freedom ($\bar{R}^2$). The Durbin-Watson statistics indicate the absence of serial correlation in all the sub-models.

It is quite interesting to note that some of the variables found significant in model 1 appear to have no influence in determining the demand for hardwood plywood imports when model 2 is used. Apart from import price and quantity variables which have been significant in all the estimated submodels, the price of domestic lumber seems to be the only other factor to have impact on import demand

Table 5.9 Results of Model 2 - Single Equation Static Demand Model: Demand for Hardwood Plywood Imports in the United States, 1967 I - 1983 IV

Submodel	Elasticity Coefficients of Independent Variables										
	PMP_t	PDP_t	PLU_t	POM_t	PK_t	Q_t	T	Constant	$\bar{R}^2$	SE (DF)	d
1	-0.994** (0.454)					0.503* (0.169)		1.680 (1.017)	0.65	.335 (65)	1.912
2	-1.017** (0.455)			-0.342 (1.188)		0.503* (0.170)		1.701 (1.025)	0.65	.335 (64)	1.918
3	-1.002** (0.458)			-0.262 (1.193)	-0.222 (0.487)	0.501* (0.169)			0.64	.335 (63)	1.917
4	-0.994** (0.453)	0.090 (0.370)		-0.944 (1.312)	-0.762 (0.697)	0.493* (0.168)	0.013 (0.011)	1.623 (1.037)	0.64	.331 (61)	1.979
5	-1.175** (0.457)	-0.351 (0.389)	1.536* (0.499)	-0.995 (1.228)	-0.557 (0.652)	0.290*** (0.167)	0.011 (0.013)	2.533 (1.052)	0.67	.312 (60)	1.869
6	-1.006** (0.452)			-0.955 (1.311)	-0.786 (0.688)	0.495* (0.168)	0.013 (0.011)		0.64	.331 (62)	1.971

Notes: Numbers in parentheses are standard errors of corresponding coefficients. The *, ** and *** indicate elasticity coefficients significantly different from zero at the 1%, 5% and 10% confidence levels, respectively, using a one-tailed test. $\bar{R}^2$, SE, DF and d are, respectively, the coefficient of determination adjusted for degrees of freedom, the standard error of the estimate, the number of degrees of freedom, and the Durbin Watson statistics.

(see submodel 5). The estimated import demand elasticity with respect to domestic lumber price carries a positive sign which is consistent with the findings in model 1 and implies that the two inputs are substitutes in residential construction. This cross-price elasticity is 1.536 and is statistically different from zero at the one percent significance level. The cross-price elasticities of demand for hardwood plywood imports with respect to the prices of other inputs and time term are insignificant even at the ten percent confidence level. Also, the elasticity coefficients are unstable in terms of their signs and contradict the findings obtained in model 1. For instance, capital input appears to be a complement of hardwood plywood imports. This observation however, cannot be supported in view of the large standard error of the cross-price elasticity.

The own-price demand elasticity of hardwood plywood obtained from the calculation of the six submodels ranges from -.994 to -1.175. These estimates are somewhat larger than the one estimated in model 1. A further discussion on the comparison of the empirical results for the different models is presented at the latter part of the present chapter. On the other hand, the elasticity of import demand with respect to residential construction activity ranges from .290 to .503. Notice that if one excludes submodel 5 which contains too many insignificant variables, the range of the estimated demand elasticities is very small.

The results presented in Table 5.9 however, do not seem to indicate strong specification bias, in fact the elasticity coefficients of the significant variables such as import price and the level of residential construction have shown little differences in the six submodels estimated (except perhaps those in submodel 5). Furthermore, the standard errors of the two parameters just mentioned have almost remained the same in all the submodels. Thus it can be inferred that a model containing few but significant variables can yield estimates that are unbiased and comparable with those obtained from a model that consists of a relatively large number of relevant but too many insignificant explanatory variables.

A number of conclusions emerges from the empirical results of model 2. First, the elasticity estimates are larger in absolute values when a single equation import demand model is utilized instead of a system of equations model. These may be the result of simultaneity bias in the former. Second, specification bias does not seem to affect the unbiasedness of the elasticity estimates of a model that constitutes only the significant relevant variables, as illustrated by submodel 1. Finally, changes in the level of residential construction activity will affect the demand for hardwood plywood imports. This latter is fairly consistent with the findings of Chuo and Buongiorno (1982, 1983), but is contrary to the results obtained earlier (model 1).

Partial Adjustment Import Demand Model

Model 3 - Table 5.10 presents the results of regressing the actual quantity of imported hardwood plywood in the current period on its price and the level of residential construction in the same period and the previous level of imports. Note that both the short and long run demand elasticities are reported in the table, but the former provide the actual estimates of model 3 while the latter are derived using the procedure noted in chapter three. Except for the lagged dependent variable (MP_{t-1}), the demand elasticities associated with the import price and activity variable are significantly different from zero at the five and one percent confidence levels respectively. Also the said elasticities have the expected signs. In terms of the explanatory power of the independent variables, the results indicate that they are comparable with those found in the previous model, as can be seen from the corrected coefficient of determination. Moreover, the Durbin's h statistic obtained implies that serial correlation in the residual is insignificant.

However, the results reveal a fast adjustment of demand for hardwood plywood imports to changes in import price and the level of residential construction. This is evident in the large value of the coefficient of adjustment β that is almost equal to one. Actually, this value is not surprising considering the availability of domestic lumber, hardboard and particleboard (not to mention the other sources of

Table 5.10 Results of Model 3 - Partial Adjustment Demand Model: Demand for Hardwood Plywood Imports in the United States, 1967 I - 1983 IV

Parameters	Elasticity Coefficients of Independent Variables		β	$\bar{R}^2$	SE	h
	Short Run	Long Run	(S)		(DF)	
Constant	1.640	1.703	.963 (1.00)	.65	.335 (64)	.261
PMP_t	-1.010(.478)**	-1.0498				
Q_t	.480(.176)*	.498				
MP_{t-1}	.037(.064)	.038				

Notes: β, s and h are, respectively, the coefficient of adjustment, the mean time lag and the Durbin's h-statistic. Refer to the note to Table 5.9 for the rest of the notations.

hardwood plywood) which can be used as substitutes for hardwood plywood imports from the ASEAN region as the price of the latter increases faster relative to the former inputs. Due to the high value of the adjustment coefficient, the short and long run demand elasticities are nearly equivalent. Notice that the mean time lag "s" for hardwood plywood imports is also reported in Table 5.10. This is defined as $1/\beta$.[173] The computed "s" implies that it takes only one quarter for the industry to adjust its import demand to changes in its price and/or residential construction activity. This short time lag in imports may be explained by the stiff competition imported hardwood plywood faces for a share of the construction dollar in the industry.

Both the short and long run own-price demand elasticities connote that the import demand for hardwood plywood is elastic. That is, given that other factors remain constant, a one percent rise in import price will result in a little more than one percent reduction in demand for the imported input. On the other hand, demand for hardwood plywood imports will vary directly with the level of residential construction as implied by the estimated demand elasticity associated with the latter variable. The level of imports in the previous period did not seem to have a major influence in determining the current level of imports and this may be due to the presence of imperfect substitutes.

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[173] See M. Goldstein and M.S. Khan (1976).

During the initial estimation of the model, the coefficient of the lagged import variable appeared to be significantly different from zero at the one percent confidence level, but the strong serial correlation in the residual led to a conclusion that the presence of this lagged dependent variable has served to enhance it. Thus the estimates of model 3 reported in Table 5.10 are the results after correction for the first order serial correlation has been performed. Given the somewhat strict assumptions embodied in model 3, an alternative model (model 4) is proposed. Two main issues are dealt with in the next model; namely, (1) to determine the appropriate pattern of lag distribution and (2) the length of lag in which the full impact of the lagged values of a given explanatory variable is highly significant (in statistical sense) to explain the variation in import demand. Also the mean lag length for each explanatory variable is estimated.

Polynomial Distributed-Lag Import Demand Model

Model 4 - Based on the results of the experimentation with the polynomial distributed lag and F-test statistics, discussed in Appendix C1, model 4 should be specified with a second-degree polynomial constrained at the extreme points. However, this particular specification (see Table C1.4 in the same appendix source) has significant positive autocorrelation that may cause biased parameter estimates and may influence other comparative static summary measures.

While use of instrumental variables can improve the parameter estimates and eliminate serial correlation in the residuals, no attempt has been done to utilize such approach in the present study for certain reasons noted in Appendix C1. Consequently, this author selected the unconstrained quadratic polynomial[174] since it does not show strong autocorrelation, while at the same time seems to better explain the variation in import demand due to a change in the price of imported hardwood plywood and level of residential construction. In addition, it has a smaller residual variance or standard error of the estimated model.

The estimated elasticity coefficients of the variables in model 4 with a polynomial lag structure of order k=4 and degree r=2 unconstrained at both end-points are reported in Table 5.11. All demand elasticities are significantly different from zero at least at the 10 percent level except for the price of other materials. In model 2, as may be noted, the price of other materials also did not appear to be significant and the present results confirm the former finding. The long run own-price demand elasticity of imported hardwood plywood is -.731. This is much smaller than those obtained for models 1 through 3, but consistently remains negative, as expected. Lagged influences of import price on hardwood plywood imports seem to be significant in the immediately two previous quarters. Moreover, the pattern of lag distribution (or distribution of the coefficients) indicates an increasing influence of past changes in import price up to two quarters and a declining significance thereafter. An implication of this finding is that the restriction implied by the both end-point constraint cannot be rejected. The calculated mean lag in import demand with respect to past levels of import price suggests that demand adjustment proceeds at a considerably rapid pace (one-half quarter).

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[174] For the implication of unconstrained or zero restriction at any end-point on the polynomial distribution, see section C below.

The long run cross-elasticity of demand for hardwood plywood imports with respect to the price of capital has an expected positive sign which is statistically significant at the five percent level. Again, the results imply that hardwood plywood imports and capital input are substitutes in residential construction; a finding similar to the one found in model 1. Two major points must be noted about the coefficients of lagged values of the price of capital. First, lagged influences show a decreasing impact up to three quarters and a significant importance in the fourth quarter. The estimated coefficient associated with the price of capital lagged four quarters bears a negative sign that is significantly different from zero at the 10 percent level. This may imply that the price of capital in the fourth quarter has a complementarity relationship between this input and imported hardwood plywood. Second, the mean lag in demand for hardwood plywood imports is approximately 4.5 quarters which exceeds the optimal lag length of 4

Table 5.11 Results of Model 4 - Polynomial Distributed-Lag Demand Model: Demand for Hardwood Plywood Imports in the United States, 1967 I - 1983 IV

Second - Degree Polynomial without End Point Restriction

Elasticity Coefficients of Independent Variables

	PMP_{t-k}	PK_{t-k}	POM_{t-k}	PLU_{t-k}	Q_{t-k}
Total effect	-.731 (.396)	1.031 (.452)	-2.409 (2.341)	-1.882 (.415)	1.525 (.909)
Current quarter	-.081 (.497)	1.204 (.894)	-1.348 (1.286)	.338 (.504)	.702 (.283)**
One quarters lag	-.528 (.195)*	1.079 (.443)**	-1.571 (.720)**	.160 (.280)	.346 (.175)***
Two quarters lag	-.561 (.332)***	.580 (.649)	-1.137 (1.028)	- .197 (.371)	.148 (.157)
Three quarters lag	-.179 (.206)	- .293 (.455)	- .048 (.829)	- .733 (.274)**	.107 (.154)
Four quarter lag	.617 (.834)	-1.539 (.839)***	1.696 (1.522)	-1.488 (.544)**	.223 (.260)
Mean Lag (No. of quarters)	0.50	4.50	1.10	4.00	1.20
Constant	-4.143 (2.272)				
$\bar{R}^2$ (DF)	.69 (48)				
Standard error	.331				
d statistic	1.416				

quarters. It is possible that the maximum lag length associated with the price of capital is longer than k=4 because, as may be recalled, only the import price and construction activity (number of housing starts) variables are used in determining the optimal value of the lag length.

The insignificance of the long run cross-elasticity of import demand with respect to the price of other materials does not warrant further discussion. One needs to note only that the price of other materials lagged one quarter seems to have a direct effect on import demand, while the mean lag in import demand due to a change in this variable is about one quarter.

The domestic lumber long run price elasticity coefficient is in contrast to a priori expectation regarding its sign and those obtained for models 1 and 2. Nevertheless the negative elasticity coefficient of domestic lumber would mean that it is a complement of imported hardwood plywood. Past changes in the price of domestic lumber tend to influence import demand in a geometrically declining pattern, but its values lagged three and four quarters appeared to have significant impacts in the current level of imports. Moreover, the mean lag in hardwood plywood imports which can be attributed to previous levels of domestic lumber price is about four quarters.

As predicted, the long-run elasticity of demand for hardwood plywood imports with respect to the level of residential construction is positive and statistically significant at least at the 10 percent level. In absolute value, the elasticity estimate is much higher than those found for models 2 and 3. The coefficients of the previous levels of construction activity display a declining impact on import demand up to three quarters and a slight increase after that. The estimated mean lag corresponding to the activity variable is 1.20 quarters, which is quite close to that particular period wherein its influence on demand for imports remains significant (i.e., one quarter lag).

C. South Korea

Static Import Demand Model

Model 1 - The results of estimated elasticity coefficients of all variables of the nine submodels that comprise model 1 appear in Table 5.12. Except for submodels 6 and 7 which assumed the absence of money illusion in import demand, all estimates seem satisfactory and satisfy the a priori expectations in terms of signs of coefficients, with the exclusion of the term reflecting the level of residential construction in the United States (see submodel 5). Also, the coefficients of multiple determination corrected for degrees of freedom are reasonably high in all submodels, with the exception of submodels 6 and 7, and hence the explanatory variables considered appear to be sufficient enough to account for the variation in demand for hardwood log imports due to changes in prices and production

Table 5.12 Results of Model 1 - Static Demand Model: Demand for Hardwood Logs Imports in South Korea, 1970 I - 1978 IV

Submodel	Elasticity Coefficients of Independent Variables PML_t	 POM_t	 POM_t	 INP_t	 QUS_t	 Constant	 $\bar{R}^2$	 SE (DF)	 d
1	-.822* (.073)					9.239 (.291)	.86	.293 (34)	2.082
2	-.897* (.054)			.852* (.132)		8.738 (.148)	.92	.212 (33)	1.951
3	-.851* (.048)	-1.292* (.428)		1.786* (.339)		8.511 (.140)	.93	.192 (32)	1.922
4	-.871* (.045)		-1.432* (.399)	1.920* (.325)		8.494 (.133)	.94	.184 (32)	1.909
5	-.850* (.048)	-1.398** (.569)		1.869* (.457)	-.043 (.161)	8.760 (.941)	.93	.209 (31)	1.917

Note: See the notes to Table 5.9 for the definition of $\bar{R}^2$, SE, DF, and d.

Table 5.12 Continued

Submodel	Elasticity Coefficients of Independent Variables							Constant	$\bar{R}^2$	SE (DF)	d
	PML_t	POM_t	INP_t	$(PML/POM)_t$	$D1_t$	$D2_t$	$D3_t$				
6				-.000 (.000)				6.474 (.253)	.35	.622 (34)	2.311
7			-.474 (.348)	-.000 (.000)				6.881 (.367)	.35	.377 (33)	2.265
8	-.855* (.054)		.751* (.136)		-.098 (.082)	.113 (.085)	.006 (.076)	8.683 (.151)	.93	.194 (30)	1.891
9	-.839* (.048)	-1.073** (.477)	1.581* (.394)		-.021 (.091)	.112 (.085)	.024 (.078)	8.497 (.154)	.93	.185 (29)	1.914

activity, among others. Moreover, the Durbin-Watson statistics reveal no trace of serial correlation in all submodels.

Estimates of own-price demand elasticity of hardwood log imports are all negative and significantly different from zero at the one percent confidence level. These estimates range from -.822 to -.897, indicating an inelastic response of import demand to a change in its price. The estimates of import demand elasticity with respect to the price of other intermediate products have the expected signs and imply a complementarity relationship between the said products and imported hardwood logs in forest products manufacturing. However, the results tend to indicate that the influence of the price of other intermediate products on import demand is significant both in its current and lagged one period values. The relatively high cross-price import demand elasticity in absolute term implies a more than one percent increase in hardwood log imports for every one percent decline in the price of other intermediate products, other things being equal, and thus reflects the basic nature of imported hardwood logs as a primary input in production of secondary wood products.

As judged from the elasticity coefficient of index of industrial production, demand for hardwood log imports will increase when production activity by the wood products manufacturing industry rises and all other factors are constant. An exception to this however is in the case of submodel 7 in which the elasticity coefficient of production index has an unexpected negative sign. However this elasticity is insignificant. The range of the estimated elasticities of demand for hardwood log imports with respect to industrial production index is from .751 to 1.920.

Apparently, the no money illusion constraint seems to be an inappropriate assumption for the South Korean wood products manufacturing industry's demand for imported hardwood logs since the relative price term coefficients in submodels 6 and 7 are not different from zero (even at the 10 percent level). Similarly, the industrial production index coefficient carries the wrong sign and is also not significant which may be a result of the restriction imposed on the price parameters. That is, the elasticity coefficients of import price and the price of other intermediate products must add to zero. The results therefore indicate that specification of import demand function for the product under consideration should not include a ratio term of import price to the price of other intermediate products. An obvious reason for this is that the selected commodities used to calculate the producer price index and, in turn, utilized here to represent the price of other intermediate products are most likely not comparable with the imported hardwood logs.

As regards the probable impact of seasonal fluctuation on import demand, results of submodels 8 and 9 did not show any significant evidence. All the coefficients of the seasonal dummies are not statistically significant, but nevertheless the negative coefficient of the first dummy variable tends to support the earlier observation about the trend of log imports. This latter point however is purely conjecture in view of the lack of significance of all dummy coefficients.

From the foregoing discussion, the following inferences emerge. First, changes in production activity and import price will affect the demand for hardwood log imports. In addition, the imported input and other domestic intermediate inputs (products) act as complements in the production of secondary wood products in South Korea. Notice that the change in production activity tends to have a larger impact on import demand than the corresponding change in import price. Second, the conventional assumption of absence of money illusion on the part of the demanders (i.e., the industry) cannot be supported in the case of the product under consideration. Finally, any pattern of import demand over time, as actually observed, cannot be due to seasonal effects. As a whole, the static import demand model employed explains a high percentage of the variation in import demand and produces reliable estimates. In the present model, it is considered that demand for imports adjusts promptly to changes in production activity and prices. An assumption such as this can, of course, only be valid if the adjustment coefficient in the next model (model 2) yields a value equal or close to one.

Partial Adjustment Import Demand Model

Model 2 - Table 5.13 reports the results of estimation of the three submodels under model 2. As evident in the table, introduction of the quantity of imported hardwood logs in the previous quarter to reflect any lag in import demand has not improved the explanatory power of either submodel. This can be discerned from a comparison of any submodel's $\bar{R}^2$ value with that of the corresponding submodel in model 1. The reason behind this is the relatively low and insignificant elasticity coefficient associated with lagged imports, indicating that past imports do not influence demand for hardwood log imports in the current period. Moreover, this would mean that the coefficients of adjustment are close to one in all submodels and as such, the points raised in model 1 about the adjustment in import demand can be fairly accepted. The estimates of adjustment coefficients range from .95 to .99 and imply a rapid adjustment in the level of imports to changes in input prices or production activity. Any lag in import demand adjustment seems to be completed in one quarter, as revealed by the estimated mean time lag of adjustment for the three submodels.

With the high coefficients of adjustment in all submodels, it is not unexpected to obtain short and long run demand elasticities for hardwood log imports that are almost equal. All elasticities of demand with respect to import price, price of other intermediate products and industrial

Table 5.13 Results of Model 2 - Partial Adjustment Demand Model: Demand for Hardwood Logs Imports in South Korea, 1970 I - 1978 IV

Submodel		Elasticity Coefficients of Independent Variable								
		PML_t	POM_t	INP_t	ML_{t-1}	Constant	β (s)	$\bar{R}^2$	SE (DF)	h
1	Short run	-.905 (.075)*			.046 (.037)	9.248 (.361)	.954 (1.0)	.86	.283 (33)	-.568
	Long run	-.949			.048	9.694				
2	Short run	-.900 (.054)*		.854 (.130)*	.031 (.027)	8.558 (.216)	.969 (1.0)	.92	.208 (32)	.063
	Long run	-.929		.881	.032	8.832				
3	Short run	-.841 (.048)*	-1.258 (.427)*	1.740 (.347)*	.010 (.028)	8.436 (.220)	.990 (1.0)	.93 (31)	.211	1.259
	Long run	-.849	-1.271	1.757	.010	8.521				

Note: See the notes to Tables 5.9 and 5.10.

production index satisfy the a priori expectations about their signs and are significantly different from zero at the one percent level. Likewise the magnitudes of these elasticities are quite consistent with the findings obtained for the static model (model 1), except the own-price demand elasticities. In all cases, the own-price import demand elasticity in the three submodels appears to be larger in absolute value than the corresponding elasticity in similar submodels under model 1. In general, the results of model 2 conform with those found for model 1.

Moreover, the three submodels did not show any significant serial correlation in the residuals as revealed by Durbin's h statistics. In contrast to the first three submodels in model 1, all but one of the submodels have smaller standard errors; the one exception is submodel 3. In spite of this improvement however, model 2 does not seem to be superior to the static model (model 1) to justify its application. The only main advantage of model 2 is that it can determine whether there are lags in the adjustment of import demand when input prices and production level changes. Model 2 also provides both the short and long run demand elasticities. However, any advantage model 2 has over model 1 depends upon the significance of the coefficient of lagged imports and other statistical characteristics.

The significant coefficient of the price of other intermediate products lagged one quarter in submodel 4 under model 1 suggests that lags in import demand can be due to expectations formation about input prices and production activity. This possibility is the main focus of analysis of the parameter estimates of model 3 below.

Polynomial Distributed-Lag Import Demand Model

Model 3 - Appendix C2 reports the outcome of the experimentation with the polynomial distributed lag to search for the appropriate degree of the interpolation polynomial, given a maximum lag length of 4 quarters. Quadratic and cubic polynomials unconstrained at the extreme points are fitted and then examined on the basis of the established criteria given in chapter four. As judged from the $\bar{R}^2$, standard error and Durbin-Watson d statistic, the experimentation led to adoption of a third-degree polynomial. The zero restriction (constraint) at any end point on the polynomial distribution indicates that the lagged adjustment exhibits an irregular pattern, probably falling at some quarters and then rising over other quarters.

The same appendix source presents the results of the F-test of the unrestricted distributed-lag model (as a maintained null hypothesis) against two alternative hypotheses: one far end-point and both end-points constrained models. The results imply that a restriction at both end-points on the interpolation distribution is acceptable at the one percent significance level. Hence there appears to be a definite pattern of lagged adjustment that is increasing (decreasing) for one or two time lags and thereafter decreases (increases). This information suggests that the assumption embodied in partial adjustment model about the pattern of lag distribution is unacceptable in the case of import demand for hardwood logs in this country.

The final specification of model 3 and its parameter estimates is reported in Table 5.14. The model performs well, with the import price and production activity coefficients having the proper, expected sign and the magnitudes of the elasticity estimates are to some extent consistent with the findings obtained for models 1 and 2. No trace of serial correlation in the residuals is found, although the adjusted coefficient of determination has declined considerably. This low value of R^2 means that slightly more than half of the variation in quarterly imports of hardwood logs can be explained by the model. The present model however, reveals some important information that have not been considered in the two previous models. First, the influence of the price of hardwood log imports on its demand remains significant up to 2 previous quarters, while the mean lag in import demand adjustment is about one quarter. Second, the impact of past changes in the level of production is significant in the two quarters lag. The mean lag in import demand adjustment resulting from past production levels is 2 quarters. Moreover, if the elasticity coefficients are to be graphed, the resulting distributions will conform with the expected shape. These results however,

Table 5.14 Results of Model 3 - Polynomial Distributed-Log Demand Model: Demand for Hardwood Logs Imports in South Korea, 1970 I - 1978 IV

Third-Degree Polynomial Constrained to Zero at the Extreme Points

Lag Number k (Quarters)	Elasticity Coefficients of Independent Variables			
	PML_{t-k}		INP_{t-k}	
Total effect	- .748		.790	
Current quarter	- .231	(.105)**	.394	(.569)
One quarter lag	- .270	(.088)*	.406	(.460)
Two quarters lag	- .192	(.034)*	.203	(.077)**
Three quarters lag	- .072	(.088)	- .045	(.458)
Four quarters lag	.017	(.105)	- .169	(.568)
Mean lag (No. of quarters)	1.10		2.00	
Constant	8.164	(.352)		
$\bar{R}^2$ (DF)	.53	(27)		
Standard error	.444			
d statistic	2.332			

seem to refute the assumption of model 2 about the equality of adjustment coefficients and hence mean time lag for import price and production activity.

The estimated long run demand elasticities of hardwood log imports are -.748 with respect to import price and .790 with respect to industrial production index. Both of these elasticities are significantly different from zero at the one percent level. One may note that the long run elasticity associated with import price is a bit lower in absolute value than the corresponding elasticity found for models 1 and 2.

As regards the performance of the present model, it is less preferable compared to models 1 and 2 in terms of goodness of fit (i.e., the ability to explain the variation in import demand).

D. Japan

Static Import Demand Model

Model 1 - OLS estimates of the three submodels of model 1 are reported in Table 5.15. The results of submodel 1 apparently indicate that demand for hardwood log imports in Japan is dependent upon import price, domestic wholesale price of the same product and the level of residential construction in the current period. This is confirmed by their corresponding elasticity coefficients that are statistically significant (at least at the 10 percent

Table 5.15 Results of Model 1 - Static Demand Model: Demand for Hardwood Logs Imports in Japan, 1979 I - 1983 IV

Submodel	Elasticity Coefficients of Independent Variables										
	PML_t	PDL_t	Q_t	$(PML/PDL)_t$	$D1_t$	$D2_t$	$D3_t$	Constant	$\bar{R}^2$	SE (DF)	d
1	.930	-1.140	.323					-.068	.75	.096	1.488
	(.177)*	(.233)*	(.180)**					(.078)		(16)	
2			.394	.025				-.258	.62	.119	1.901
			(.231)	(.078)				(.092)		(14)	
3	.723	-1.003	.432		-.088	-.135	-.061	.013	.80	.086	1.736
	(.216)*	(.294)*	(.289)		(.052)	(.063)***	(.047)	(.100)		(13)	

Note: See the note to Table 5.9.

level). The positive elasticity coefficient for import price is unexpected but not without explanation. It may be noticed that the two price variables refer to only one intermediate product, the imported hardwood logs, and have coefficients with opposite signs. An implication of this is that imports of hardwood logs from the ASEAN region will increase even if its price rises so long as its domestic wholesale price and construction activity in Japan remain unchanged. However, if its domestic wholesale price moves upward, import demand will decline substantially and consequently offset the positive impact of import price. This is deducible from the estimated demand elasticities of imported hardwood logs of -1.140 with respect to its domestic wholesale price and .930 with respect to import price.

The high coefficient for domestic wholesale price is an indication of relatively elastic demand for hardwood log imports. Similarly, it reflects the stiff competition hardwood logs face in the Japanese market and in the residential construction in particular.

As predicted, the elasticity coefficient associated with the number of new dwellings constructed in each quarter is positive. It implies a rise in the quantity of hardwood logs to be imported when there is an expansion of construction activity and all other factors are constant. The lower significance of the construction activity coefficient can be attributed to the generally low economic growth, high mortgage rates and large scaled depreciation of yen during most part of the years covered by this study. Thus it can be stated that during the sample period, the domestic wholesale price of hardwood logs has been an important factor in determining the demand for hardwood log imports. Up to the latter part of 1982, both the wood products manufacturing and residential construction industries had been depressed due to relatively low economic growth rates which started after the oil price hike in 1973-74.

When the import price is divided by its domestic wholesale price to examine the plausibility of the no money illusion constraint (i.e., a symmetric response of demand for imports to domestic and import prices), the explanatory power of model 1, as illustrated by the results of submodel 2, has declined remarkably. Likewise, all elasticity coefficients are not significant, indicating the inappropriateness of the said assumption. This finding confirms the results obtained by Nomura and Yukutake (1983), although they used somewhat different price variables and dealt with total timber demand in Japan.

Estimated elasticities of submodel 3 also support the findings of Nomura and Yukutake (1983) regarding the effects of seasonal variation on demand for hardwood log imports. The results reported in Table 5.15 suggest that there has been a significant negative impact on import demand due to seasonal fluctuations that occured in the second quarter. Although the other dummy variables have insignificant coefficients they somehow conform with those of Nomura and Yukutake in terms of their (expected) signs. Explicit account of seasonal effects helps improve the explanatory power of model 2 as revealed by the larger coefficient of determination adjusted for degrees of freedom in submodel 3 compared to the corresponding values in submodels 1 and 2. However, one should note the decline in the elasticity coefficients of import price and domestic wholesale price and the insignificant coefficient of construction activity. One possible explanation for the significant coefficient of the seasonal dummy variable in the second quarter (-.135) is the liquidation of hardwood logs (including processed products) inventory during this period where demand for housing is usually anticipated to be high.

Despite the relatively short time series data, the model used yields reliable results and provides relatively good fit to the data.

Partial Adjustment Import Demand Model

Model 2 - That import demand for hardwood logs in the short run can only be adjusted partially to its desired, long run level cannot be rejected in the case of Japan. Both submodels 1 and 2 yield elasticity coefficients for lagged imports that are significantly different from zero at the one percent level (Table 5.16). As a consequence of the significance of lagged imports, the short run demand elasticities are all less than the long run elasticities and

Table 5.16 Results of Model 2 - Partial Adjustment Demand Model: Demand for Hardwood Logs Imports in Japan, 1979 I - 1983 IV

Submodel		Elasticity Coefficients of Independent Variables									
		PML_t	PDL_t	Q_t	$(PML/PDL)_t$	ML_{t-1}	Constant	β (s)	$\bar{R}^2$	SE (DF)	h
1	Short run	.510 (.170)*	-.621 (.217)**	.336 (.136)**		.433 (.118)*	-.052 (.057)	.57 (3.5)	.83	.079 (15)	-.386
	Long run	.895	-1.089	.589		.760	-.091				
2	Short run			.413 (.151)**	.086 (.064)	.622 (.110)*	-.174 (.069)	.38 (6.0)	.77	.093 (.16)	.288
	Long run			1.087	.226	1.637	-.458				

Note: See the notes to Tables 5.9 and 5.10.

therefore support the a priori arguments about the stock adjustments that have been observed in several levels of distribution channels.

Except for the relative price term in submodel 2, all other explanatory variables remain statistically significant and have long run elasticity coefficients that are, to some extent, in conformity with those found for model 1 in terms of signs and magnitudes. An exception to this latter point is the elasticity coefficient of the number of new dwellings constructed each quarter which appears to be higher in absolute value than the corresponding coefficient obtained earlier. Moreover, the explanatory power of the submodels have improved with the inclusion of lagged imports as an explanatory variable.

In submodel 1 the positive coefficient of the lagged dependent variable implies an increase in the level of imports as a result of the previous imports. The results of submodel 1 further indicate that quarterly imports could adjust to a change in prices or construction activity by about .57 percent for every one percent change in the latter. This is equivalent to a mean time lag of adjustment of about one-and-one-half quarters. The estimated mean lag for submodel 2 however, may not be reliable because of the possible biased coefficient on lagged imports owing to the inclusion of the insignificant price term. As in model 1, the assumption of linear homogeneity in prices cannot be accepted up to this point.

Of the two submodels considered, submodel 1 is preferable when it comes to goodness of fit and minimal residual variance or standard error of the estimate. Both submodels however, did not show any significant serial correlation in the residuals. It is interesting to note that model 2 better fits the data than model 1. This may be due to the ability of the partial adjustment model to capture any response lags in import demand arising from a change in any of the explanatory variables which model 1 is not able to. Further comparison of the empirical performance of the models will be discussed in the next section.

Polynomial Distributed-Lag Import Demand Model

Model 3 - The hypothesis that current demand for hardwood log imports is a function of the current and past levels of import price and construction activity is acceptable. Support for this claim can be readily ascertained from the results of model 3 estimation reported in Table 5.17. At this point, it is appropriate to mention a few features of the model which relate to the manner in which the lags are distributed over time due to changes in the explanatory variables, before discussing individual estimates of model 3. The results of experimentation with the polynomial distributed lag, presented in Appendix C3, suggest a second-degree polynomial for the present model, which may indicate a single turning point in the distribution of the coefficients of lagged parameter values. Furthermore, the

Table 5.17 Results of Model 3 - Polynomial Distributed-Lag Demand Model: Demand for Hardwood Logs Imports in Japan, 1979 I - 1983 IV

Second-Degree Polynomial without End Point Restriction

Lag Number K (Quarters)	Elasticity Coefficients of Independent Variables			
	PML_{t-k}		Q_{t-k}	
Total Effect	1.073		.443	
Current quarter	.502	(.278)	.348	(.162)***
One quarter lag	.238	(.067)*	.217	(.106)***
Two quarters lag	.094	(.111)	.087	(.103)
Three quarters lag	.071	(.070)	- .041	(.099)
Four quarters lag	.169	(.199)	- .168	(.199)
Mean lag (No. of quarters)	1.00		1.00	

Constant	-7.08	(.165)
$\bar{R}^2$ (DF)	.65	(9)
Standard error	.077	
d statistic	2.485	

F-test statistics imply that the polynomial distribution should be unconstrained. Due to these characteristics the model has produced coefficient estimates for import price and construction activity that have no definite distribution pattern over the period covered by this study. Careful investigation of the distribution of the lagged parameter coefficients reveals that the implicit assumption of model 2 above regarding the geometrically declining pattern of the impact of previous values of the explanatory variables on the current level of imports can neither be accepted nor rejected *in toto*. Its possible rejection comes from the coefficients of current and previous levels of import price that tend to exhibit a declining significance of its impact on current imports with the passing of each quarter up to 3 quarters lag but then increases after. On the other hand, model 2 assumptions describe the distributional pattern of the construction activity coefficients. It follows from these results that in so far as the above-stated assumption is concerned, model 2 is valid only in the case of the expected influence of past changes in residential construction activity on current demand for hardwood log imports.

The estimated elasticity coefficients associated with import price are positive, which again indicate that import demand will change directly with its price. The coefficient of import price lagged one quarter is significant at the one percent confidence level and this would imply that current demand for imports is influenced by its price in the preceding quarter. It would have been more meaningful and desirable to have coefficient estimates for the domestic wholesale price of imported hardwood logs in interpreting the coefficients of lagged values of import price to examine whether the negative effect of the former remain stronger than the positive impact of the latter, as observed from the results of models 1 and 2. Unfortunately, the short time series available precludes this operation. The omission of the domestic wholesale price as an explanatory variable might be the reason for the sudden increase in absolute value of the long run own-price demand elasticity of hardwood log imports. The results also imply that a change in the price of imports may result in a mean lag of one quarter in demand adjustment. The positive coefficients of current and previous values of import price are more difficult to explain without sufficient information on the other factors affecting import demand.

The results in Table 5.17 further indicate that the current and previous (lagged one quarter) levels of residential construction in Japan directly influence the current demand for hardwood log imports. This particular finding is quite consistent with the results obtained by McKillop (1973) in his study of Japanese demand for the U.S. logs and lumber and for Canadian lumber. It may well be that new orders are made in response to the variation in construction activity in the most recent period and in anticipation of high demand in the near future. One interesting result reported in Table 5.17 is the estimated mean time lag in the adjustment in the quantity of imports to changes in the level of residential construction. It is about one quarter, which is equal to the mean time lag attributed to import price change and approximates the mean lag (i.e., 1.70 quarters) estimated for model 2 (submodel 1). It therefore appears that, in the case of hardwood log imports, there is a lag in the adjustment of imports in response to changes in construction activity and import price.

The estimation results for the static, partial adjustment and polynomial distributed-lag models can be summarized as follows: First, for the static import demand model (model 1), the estimated coefficients of the number of new dwellings constructed each quarter, used to represent the level of residential construction, and domestic wholesale price of imported hardwood logs have the expected sign and are statistically significant (at least at the 10 percent level). The coefficient on import price however, has an unexpected (positive) sign which is significantly different from zero at the one percent level. Second, demand for hardwood log imports does not show a symmetric response to domestic wholesale and import prices. In fact, in both models 1 and 2, the current level of imports has responded more strongly to changes in domestic wholesale price than import price. This suggests that the assumption of no money illusion on the part of the residential construction industry and general trading firms cannot be accepted. Third, seasonal fluctuations appear to have a negative impact on imports, more specifically during the second quarter of the year. Fourth, the results support the hypothesis that the response of hardwood log imports to changes in prices and construction activity is subject to adjustment and expectation lags. These lags may also be due to delivery lags. But the findings show that these are relatively short, about one to two quarters on the average. In relation to the impact of past changes in import price and residential construction activity, the results for the polynomial distributed-lag model (model 3) imply a fast decreasing impact of construction activity over the four-quarter period, with most of the response of imports occurring in the first quarter. For the import price variable, the lag distribution suggests that its influence on imports declines in significance up to three quarters lag and increases after, indicating an inverted bell-shaped or v pattern. Finally, the empirical results do not find strong support for the implicit assumption of model 2. In other words, the geometrically declining pattern of lag distribution may not be appropriate for hardwood log imports. The significance of lagged imports reflecting adjustment lags as well as the importance of expectation lags in import demand confirm the soundness of models 2 and 3, although model 2 still embodies a limiting assumption, as noted above. Further comparison of the models' performance is presented below.

E. Some Comparisons of the Import Demand Models' Performance

The preceding sections have presented the results of the application of static, partial adjustment and polynomial distributed-lag demand models to an empirical study of import demand for hardwood logs in South Korea and Japan, and for hardwood plywood in the United States. In the discussion of the results however, much emphasis has been devoted to significance and sizes of parameter estimates as well as values of some test statistics. Little has been mentioned about the relative advantage of a particular model over the others. This section thus purports to compare the suitability of the demand models. Ideally a good basis of comparison is to test the predictive ability of the models for a new set of data. This means that additional series for the various variables considered have to be collected and used for forecasting imports. Two of the most common statistical tests used to examine the superiority of one model over the others are Theil's U-statistic[175] and mean square error; an application of these can be found in Chou and Buongiorno (1982). Due to inaccessibility of the needed data and time constraints, a comparison of the models is performed merely on the ability to explain the variation in imports. More specifically, the appropriateness of the models is determined through the unexplained proportion of total variation in imports about its mean. The lower the proportion of total variation in imports that is not explained by the model, the more desirable and appropriate it is. This measure may be regarded a crude one, but nonetheless can serve the present purpose. In addition, the literature provides evidence that this measure yields information concerning the performance of the models consistent with such measure as Theil's U-statistic, although the latter may give a better distinction.

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[175] H. Theil, *Economic Forecasts and Policy* (Amsterdam:North-Holland, 1966).

This measure is normally given by $[1-R^2]$, where R^2 is the unadjusted coefficient of determination. Since the number of parameters (and hence degrees of freedom) differs in each of the models, the measure has to be corrected for degrees of freedom. The resulting measure modified to account for degrees of freedom is $[1-\bar{R}^2]$, where $\bar{R}^2$ is as defined previously. Clearly, this measure is equivalent to determining the goodness of fit of a model. However, in time series studies one can obtain higher values of $\bar{R}^2$ even though the model does not really provide a better explanation of a large proportion of the variation in imports. It could well be that some of the explanatory variables grow over time. To improve the basis of comparison, the standard error (SE) of the estimate (regression equation) is also examined. Smaller SE will imply a good fit and larger SE, a poor fit. The use of variables in index terms reduces the possible bias on the values of SE owing to the units of measurement.

Table 5.18 gives the values of [$1-\bar{R}^2$] in percentage terms and the standard errors of the regression for the four models postulated for the United States. On the whole the translog model (model 1) completely dominates the rest of the import demand models. The polynomial distributed-lag model shows a slight advantage over the static (model 2) and partial adjustment (model 3) models in terms of smaller unexplained variation in demand for imports. Apart from this, there is no strong evidence to support the polynomial distributed-lag model over the other two single equation models (models 2 and 3). In sum, it is preferable to use a translog model in analyzing the demand for imports of hardwood plywood in the U.S. residential construction industry. This kind of argument may also be true in the case of hardwood log imports in Japan and South Korea, if only data had permitted that model to be used. It may be noted that the insignificance of the coefficient of lagged imports in the partial adjustment model (model 2) has made it just as good as the static model (model 1).

In Table 5.19 the values of [$1-\bar{R}^2$] in percentage terms and standard errors of the regression for the three models postulated for South Korea are reported. To facilitate the comparison, one can compare model 3 with submodel 2 of models 1 and 2, which reflect only the influences of production activity and import price on imports. On the basis of the established criteria, static and partial

Table 5.18 Comparison of Demand Models on the Bases of Goodness of Fit and Minimum Standard Error of the Estimate: Demand for Hardwood Plywood Imports in the United States, 1967 I - 1983 IV

MODELS (Submodels)	$[1-\bar{R}^2] \times 100$	SE
1. Homothetic, non-neutral technical change translog model	12.00	.125
2. Single equation, static model		
(1)	35.00	.335
(2)	35.00	.335
(3)	36.00	.335
(4)	36.00	.331
(5)	33.00	.312
(6)	36.00	.331
3. Partial adjustment model	35.00	.335
4. Polynomial distributed-lag model	31.00	.331

Table 5.19 Comparison of Demand Models on the Bases of Goodness of Fit and Minimum Standard Error of the Estimate: Demand for Hardwood Logs in South Korea, 1970 I - 1978 IV

MODELS (Submodels)	$[1-\bar{R}^2] \times 100$	SE
1. Static demand model		
(1)	14.00	.293
(2)	8.00	.212
(3)	7.00	.192
(4)	6.00	.184
(5)	7.00	.209
(6)	65.00	.622
(7)	65.00	.377
(8)	7.00	.194
(9)	7.00	.185
2. Partial adjustment model		
(1)	14.00	.283
(2)	8.00	.208
(6)	7.00	.211
3. Polynomial distrbuted-lag model	47.00	.444

adjustment models seem to perform equally well and are superior to the polynomial distributed-lag model. However, the partial adjustment model gives a smaller standard error compared to the static model. Unless new evidence becomes available there is no substantive reason to discriminate the static model in favor of partial adjustment model considering the nonsignificant coefficient on lagged imports in the latter. In other words, since the lagged imports did not indicate any effect on current demand, it means that the implicit assumptions of the static model (i.e., instantaneous adjustment of imports to changes in import price and construction activity) cannot be rejected. One possible explanation for the poor performance of the polynomianl distributed-lag model could be the linear dependency between the current and previous (lagged one quarter) levels of production activity which, though did not exceed 0.80, may have enlarged the standard error of the estimate. Nevertheless, the relative advantage of this model (model 3) to permit examination of the pattern of lag distribution which is not taken into account in model 1 and imposed a priori in model 2 should be noted.

When it comes to hardwood log imports in Japan, the three demand models postulated perform quite differently (see Table 5.20). The two submodels of the partial adjustment model (model 2) show the lowest unexplained variation. Also model 2 has improved the value of the standard errors compared to model 1. These results suggest

Table 5.20 Comparison of Demand Models on the Bases of Goodness of Fit and Minimum Standard Error of the Estimate: Demand for Hardwood Logs Imports in Japan, 1979 I - 1983 IV

MODELS (Submodels)	$[1 - \bar{R}^2] \times 100$	SE
1. Static demand model		
(1)	25.0	.096
(2)	38.0	.119
(3)	20.0	.086
2. Partial adjustment model		
(1)	17.0	.079
(2)	23.0	.093
3. Polynomial distributed - Lag model	35.0	.077

that a partial adjustment model should be utilized instead of a static model owing to the significance of the lagged imports coefficient. Unfortunately, the results for the polynomial distributed-lag model (model 3) cannot be directly compared with any of the submodels belonging to the other two models because of the omission of the domestic wholesale price variable in the former. Roughly speaking, the polynomial distributed-lag model is bested by the partial adjustment model and, to some extent, by two out of three submodels under model 1 with respect to $[1-\bar{R}^2]$ criterion. On the other hand, both the static and partial adjustment models are dominated by the polynomial distributed-lag model in terms of the standard error criterion. It is suspected that the decrease in the coefficient of determination adjusted for degrees of freedom in model 3 is a result of the noninclusion of the domestic wholesale price variable. In view of this, it is difficult to judge on the basis of the present criteria the appropriate model between the partial adjustment and polynomial distributed-lag models. However, the results suggest that it is advantageous to use a polynomial distributed-lag model when no a priori information exists about the pattern of lag distribution. Definitely, these two models should be preferred over the static model.

The comparison of the performance of the different demand models completes the discussion of the empirical results of this study. In the next section, the relevant demand elasticities and major findings of this chapter are presented.

F. Summary

Tables 5.21 to 5.23 summarize the estimated long run demand elasticities with explanatory variables that were found to have significant impact on import demand for the ASEAN hardwood plywood in the United States, and hardwood logs in South Korea and Japan respectively. As can be noticed from these tables, there have been marked differences among the estimates which may be the result of the differences in the models and, to a certain degree, estimation techniques used. Comparing these estimates with those obtained by other authors is difficult because of the differences in the specification of the models, method of estimation, sample period and definition of specific variables. Moreover, some authors did not consider either of the imported inputs in their models; for example see Rockel and Buogiorno (1982). Thus comparison of the parameter estimates found in this study with other findings cannot be done more conclusively.

Based on the empirical analysis, the following conclusions can be drawn with regard to the United States demand for hardwood plywood imports:

1. The results for the various models (see Table 5.21) indicate that, on average, the demand for hardwood plywood imports is more likely elastic. This suggests

Table 5. 21 Long-run Demand Elasticities of Hardwood Plywood Imports: The United States, 1967 I - 1983 IV

Models	Independent Variables					
	PMP_t	PDP_t	PLU_t	PK_t	PL_t	Q_t
Model 1	-.880	-.604	.022	1.558	-.096	
Model 2						
1	-.994					.503
2	-1.017					.503
3	-1.002					.501
4	-.994					.493
5	-1.175		1.536			.290
6	-1.006					.495
Model 3	-1.049					.480
Model 4	-.731		-1.882	1.031		1.525

Notes: Model 1 - Homothetic nonneutral translog (cost function) model with instantaneous adjustment assumption in import demand due to changes in relevant explanatory variables
2 - Single equation, static demand model
3 - Partial adjustment demand model
4 - polynomial distributed-lag demand model

The elasticity estimates were taken from tables 5.4, 5.9 to 5.11.

Table 5.22 Long-run Demand Elasticities of Hardwood Log Imports: South Korea, 1970 I - 1978 IV

Models	Independent Variables			
	PML_t	POM_t	POM_{t-1}	INP_t
Model 1				
1	-.822			
2	-.897			.852
3	-.851	-1.292		1.786
4	-.871		-1.432	1.920
5	-.850	-1.398		1.869
8	-.855			.751
9	-.839	-1.073		1.581
Model 2				
1	-.949			
2	-.929			.881
3	-.849	-1.271		1.757
Model 3	-.748			.790

Notes: Model 1 - Static demand model
2 - Partial adjustment demand model
3 - Polynomial distributed-lag demand model
The elasticity estimates were taken from tables 5.12 to 5.14.

Table 5.23 Long-run Demand Elasticities of Hardwood Log Imports: Japan, 1979 I - 1983 IV

Models	Independent Variables			
	PML_t	PDL_t	Q_t	ML_{t-1}
Model 1				
1	.930	-1.140	.323	
3	.723	-1.003		
Model 2				
1	.895	-1.089	.589	.760
Model 3	1.073		.443	

Notes : Model 1 - Static demand model
2 - Partial adjustment demand model
3 - Polynomial distributed-lag demand model
The elasticity estimates were taken from tables 5.15 to 5.17.

that potential gains from increased domestic processing and trade of plywood are less likely to arise from increases in its price.

2. In the residential construction industry, imported hardwood plywood has been used as a substitute for capital and domestic lumber, and complement for domestic plywood and labor.
3. Biased technical change in the residential construction industry over the years covered by this study, has been imported hardwood plywood saving.
4. Import demand for hardwood plywood has been subject to expectation formation on input prices and level of residential construction. Current demand for the imported input was affected by its price in the current and immediate two previous quarters. The results further indicated a fast adjustment of import demand to a change in import price, with a mean time lag of adjustment of one-half quarter.
5. Stock adjustment and other constraints outlined in chapter three, as judged by the coefficient of lagged imports, have no significant effect on the determination of current level of import demand. In general, import demand has been effectively adjusted to changes in import price and construction activity, and any time lag in the adjustment was usually completed within one quarter.
6. Depending on the models used, the degree to which the

imported input could be substituted for other factor inputs would differ, even though the substitution-complementarity relationships have largely remained consistent. Given the advantage of model 1 over the other models, results for the former model should be used in prediction purposes.

7. In relation to the secondary objective of this study, model 1 which was characterized by a homothetic nonneutral translog cost function dominated the other models in terms of goodness of fit and least standard error of the estimates and produced efficient parameter estimates of import demand.

In South Korea, the major conclusions concerning import demand for hardwood logs were as follows:

1. All the long run own-price import demand elasticity estimates were less than unity in absolute value, indicating an inelastic demand for the imported input.
2. Import demand has been adjusted more quickly to an import price change than a production activity change. The estimated mean time lag of import adjustment was approximately one quarter with respect to its price and two quarters with respect to production activity. In general, there was a fast adjustment of imports to changes in the explanatory variables considered.
3. Demand for hardwood log imports was sensitive to current and past values of the three explanatory variables.
4. Any pattern of imports actually observed over time

cannot be due to seasonal effects nor adjustment lags. Expectations on import price and production activity were more likely the reason for such pattern.

5. As far as the performance of the models is concerned, there was no substantive reason to discriminate use of any particular model, especially between static and partial adjustment models. It may be noted that these two models performed equally well and were relatively superior than the polynomial distributed-lag model in terms of goodness of fit and least standard error of the regression estimate.

Subject to any limitations of this study, the empirical analysis of demand for hardwood log imports in Japan led to the following conclusions:

1. The influence of import price on hardwood log imports was especially surprising and indicated a direct relationship with import demand. However, the larger elasticity coefficient of domestic wholesale price in absolute value, which has a negative sign, than import price suggests that a symmetrical change in both prices will result in a decline in demand for hardwood log imports.
2. It is quite clear from the above conclusion that demand for hardwood log imports does not respond symmetrically to changes in import price and domestic wholesale price. Thus the hypothesis pertaining to absence of money illusion on the part of the principal user (i.e., the

residential construction industry) was rejected. In fact, the results of estimation have proven in most cases that import demand was sensitive more to its domestic wholesale price than import price.

3. Seasonal fluctuations appeared to have a negative effect on hardwood log imports. This effect was particularly significant in the second quarter.
4. Import demand for hardwood logs has been subject both to adjustment lags and expectations on future import price, domestic wholesale price of this product and levels of housing construction. However, the mean time lag in the adjustment of import demand with respect to these explanatory variables was not substantially long (one to two quarters).
5. The combination of adjustment lags and expectation effects indicated the appropriateness of partial adjustment and polynomial distributed-lag models to measure the import demand for hardwood logs.

In the case of Japan, the direction of the effect of import price on import demand is contrary to economic theory, with the import price elasticity being positive. On the other hand, the high domestic wholesale price elasticity of hardwood log imports in Japan suggests that import demand is strongly affected by domestic price rather than import price. This is an interesting result and should be important information for the ASEAN producers. This finding however is not unexpected considering the fact that import price has always been lower than domestic price of the product in question, while hardwood log imports face stiff competition in the Japanese market, with those products coming from other supplying countries.

Secondly, the results imply that import demand in the three countries under consideration has been adjusted in a relatively short time period (i.e., one to two quarters lag) in response to changes in import price and activity variable. Finally, import demand has been subject to expectations on future import price and the level of residential construction or production activity. However, import demand in South Korea appears to be the most price inelastic (taking into account the results of all the models estimated) compared to the demand for imports in Japan and the United States, reflecting the basic nature of hardwood log imports as a primary input in production of secondary wood products in the former country. Similarly, a change in production activity in South Korea would more likely lead to larger variation in import demand than a proportionate change in the level of residential construction in Japan or the United States.

VI. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. Summary and Conclusions

An analysis of import demand for ASEAN hardwood logs in Japan and South Korea, and hardwood plywood in the United States was the primary purpose of this study. The dearth of information concerning the factors governing foreign demand for ASEAN forest products, while recognizing the overdependence of the region's forest industry on the foreign market, provided the rationale for the study.

Two concerns stood out during the conduct of the study. Firstly, the importance of the principal users (major wood using sectors) of imports in Japan, South Korea and the United States, or in foreign markets in general, was emphasized. It has been argued and shown in chapter two that foreign demand depends greatly on the activities (e.g., housing construction) of the principal users. For this reason, the focus of analysis centered on major wood using sectors. The second pertains to the question of which of the demand theories was appropriate to describe the import demand for hardwood logs and plywood.

Attempts to determine the factors affecting foreign demand through an analysis of the geographical direction, distribution channels and trends of trade in hardwood logs and plywood also provided the background on the principal users of imports in foreign markets. This also disclosed potential markets and competitors. A more detailed analysis of the three importing countries of interest reveals that the residential construction industry is the principal user of imports in Japan and the United States, while in South Korea, it is the plywood manufacturing industry.

To decide which theory might be most appropriate, the consumer and derived demand theories were reviewed. This led to the adoption of the derived demand theory. The consumer demand theory, utilized in early forest sector demand studies, was not used. Reasons for this are given in chapter three and relate to the fact that derived demand theory recognizes the fundamental nature of the forest products as intermediate products, and as one of the many inputs in the production function of the wood using industry, something which the consumer demand theory does not. The theory then served as a guide in constructing the import demand models and helped in selecting important variables for study. Four models were formulated (and discussed in chapter four), all in accordance with the theory. These were the single equation static, partial adjustment and polynomial distributed-lag demand models as well as the homothetic nonneutral translog cost function model. Using quarterly time series data (1967-83 for the United States, 1970-78 for South Korea and 1979-83 for Japan) and the above models, the factors affecting import demand were examined statistically and the relevant demand elasticities, the time lag in import demand adjustment and the pattern of lag structure were estimated. Due to data constraints however, the translog model was used only for the study of import demand for hardwood plywood in the United States. For the same reason, the degree of substitution or complementarity between hardwood log imports and other domestically-produced wood products and other inputs in Japan and South Korea was not investigated.

A great number of similarities were observed both in the factors influencing import demand in Japan, South Korea and the United States and in the relative efficiency of the principal users in these countries to adjust their import demand to changes in economic conditions. In general, the estimates of import demand elasticities for hardwood logs and plywood for the three importing countries (see Tables 5.21 to 5.23) complement the findings of past studies and are very useful in analyzing policy issues and in making short term forecasting on import demand.

The results of this study reveal that import demand in Japan, South Korea and the United States is sensitive to changes in import price and the level of residential construction or production activity, irrespective of product types. Import demand in South Korea and the United States fluctuates inversely with import price. However, the own-price demand elasticity estimates indicate that import demand is inelastic in South Korea and elastic in the United States (taking the average of the calculated own-price elasticities for the different demand models). In Japan, the direction of the effect of import price appeared to be contrary to economic theory as revealed by the highly significant own-price demand elasticity for hardwood log imports. This study found that domestic wholesale price of imported hardwood logs has a stronger influence than import price on Japanese import demand. Therefore, the conclusion is that import price has minor importance in determining import demand for ASEAN logs in Japan. This finding confirms earlier results by McKillop (1973) in his study of Japanese demand for North American logs and lumber. The lower import price relative to domestic wholesale price of hardwood log imports may have contributed to the lesser importance of the former variable.

The inelasticity of import demand in South Korea reflects the inability of the domestic timber supply to meet the requirement of its wood processing industry. This explains the high dependency of this industry on foreign log supply and hence its vulnerability to supply variation. This result has important implications for the ASEAN producers. An inelastic import demand indicates that ASEAN producers could increase their export earnings through supply adjustments to drive up import price.

In all the three importing countries, import demand is directly related to the level of residential construction or production activity. However, a change in the level of wood processing activity in South Korea would result in a larger variation in import demand than a proportionate change in the rate of housing construction in Japan or the United

States.

The results of partial adjustment and polynomial distributed-lag demand models reveal that the mean time lag in import demand adjustment ranges between one and two quarters. Similarly, the estimated coefficients of adjustment have been very close to one. Hence, this study concludes that the principal users in Japan, South Korea and the United States have been efficient and successful in adjusting their levels of import demand in response to variation in import price, residential construction or production activity and prices of other inputs. Stated differently, fluctuations in price of either hardwood logs or plywood would be reflected quickly in the quantity demanded of imports.

The residential construction industry in the United States has used imported plywood as a substitute for capital and domestic lumber, and complement for (softwood) plywood and labor. The results showed an increase in the substitutability between hardwood plywood imports and capital over time along with a decrease in the substitutability between the former input and domestic lumber. This is essential information for policy analysis. If this trend will continue, one could expect an increasing use of capital intensive equipment and a reduction in the use of imported hardwood plywood, labor and domestic lumber in residential construction. This development in input use would have a substantial negative impact on import demand

and it appears that the only way to increase the dollar share of hardwood plywood imports in this industry is to make its price more competitive with capital. The effects of biased technical change, whichindicate that the technology underlying the industry has been hardwood plywood imports saving and capital using during the period 1967 to 1983, reinforce this conclusion. The flexibility of imported hardwood plywood use in residential construction has serious implications for the ASEAN forest industry, especially for the plywood producers. This means that the desire to increase their export earnings may not be achieved by relying on import price. Steps to reduce cost in producing plywood can be of substantial benefit to ASEAN processors as this would allow them to lower the plywood price and still increase their sales revenue. Consideration should also be given to diversify markets for processed products such as plywood and develop new products such as particleboard.

Other variables which showed significant impact on import demand are the principal users' expectation on future input prices and levels of housing construction or production activity as well as seasonal fluctuations. The ASEAN producers would likely benefit if production of hardwood logs, and certainly of the processed products, could be regulated and scheduled in time when there is a high demand in foreign markets. This emphasizes the value of following economically-sound supply management principles in the growth of the ASEAN forest industry as a whole.

This study indicates that, in general, foreign markets should not be treated as homogeneous since their demand displays different sensitivity to factors influencing it.

This study however, has some limitations. Firstly, some variables used were proxy variables which likely resulted in biased parameter estimates. Hence, cautious interpretation of results is required. Unfortunately this problem could not be avoided at the time of the study due to the unavailability of data. On the other hand, the direction of the influence of each estimated variable appeared to be consistent with published literature. Moreover, the data problem calls for further study as more accurate data become available. The present study also considered only a few variables that could affect import demand in Japan and South Korea (also due to data constraints). It is possible that factors such as mortgage interest rates and exchange rates of yen or won will have an impact on demand for hardwood log imports and should be taken into account in future research. To minimize the impact of exchange rates, this study converted prices in national currencies. A major limitation of this study is that no attempt has been made to take into account the effects of trade policies in the importing countries. These have been known to be very responsive to policy changes in the producing countries. Processed products will probably encounter higher import tariffs and related restrictions than unprocessed products.

B. Policy Implications and Recommendations

This study was made with the end view of providing more information about the import demand for ASEAN forest products to enable the ASEAN governments to effect the regional policy on increased domestic processing and exports of value-added products. Moreover, the analysis of import demand can shed some light into the feasibility of the log export restriction policy. The policy implications that could be distilled from this study are many and require a separate discussion for each market.

South Korea

The inelasticity of import demand for ASEAN hardwood logs in South Korea suggests that the ASEAN's foreign exchange earnings and returns to timber producers could be increased through supply restrictions. However, these restrictions do not mean a complete ban on log exports. Increasing gains from restriction, however, also depends on the slope of the excess ASEAN log supply curve. The excess supply curve will determine if world price of hardwood logs will rise enough, relative to the domestic price of the same product, to maximize the gains or minimize the losses associated with the restriction. Given an inelastic import demand for hardwood logs in South Korea, an elastic log supply and the restriction of log exports will drive up the world price and lower the domestic price. However, the fall in domestic price will be less than a similar fall in the case of an inelastic log supply. Such a policy can result in more benefits in terms of increased foreign exchange to the ASEAN, higher revenue for timber producers, and cheaper logs for domestic processors. Lower domestic prices also serve as an incentive for greater domestic processing. However, an elastic log suply is unlikely in the case of hardwood logs from the ASEAN countries. Available information suggests that, in general, the supply of ASEAN forest products is inelastic, especially in the short run. Forest policy aimed at restricting log exports, where its supply is inelastic, may lead to a net-loss to the ASEAN resulting from misallocation of resources used in timber production. This indicates a considerable loss in benefits to ASEAN timber producers. Hence, the log export restriction (or export quota) policy should be modified or changed in light of the current situation. Also the decision to restrict log supply, say, to South Korea is better left to the timber producers. Export restrictions drive a wedge between world and domestic prices. A useful export policy will either minimize this price differential or try to capture the gains from increased world prices.

Results for South Korea suggest that flexible-rate export charges on logs would be the best form of policy. Higher export charges, for instance, will not only reduce log exports but will also yield additional revenue from those logs exported. At the same time, these charges can serve to encourage greater processing domestically. The appropriate level of export charges should vary with the stumpage value of logs in the world market as well as with log grade and species class. Alternatively, a flexible ad valorem charge may be considered. This can be based on posted export prices instead of the declared FOB prices which are predisposed to under-reporting problem.

The ASEAN governments should also consider the creation of a market development fund to assist timber producers to introduce lesser known timber species in South Korea and other markets. This fund would facilitate the establishment of markets for lesser known species which are suitable for veneer, plywood and particleboard production. Return to this fund could be substantial in terms of additional foreign exchange and efficient utilization of forest resources. Export of logs of lesser known species should not be taxed to provide further incentive.

Japan

The oligopsonistic nature of the importing firms in Japan indicates that they are likely well organized and posses some market power, such as determining import price. This explains partly the minor importance of import price in Japanese import demand for hardwood logs. To neutralize the market power of the importing firms, closer cooperation between the forest industry and governmental agencies in the ASEAN region should be promoted. Negotiations between Japanese importers or government and representatives of

ASEAN governments and private sectors should be explored, to determine the price of hardwood logs that would be equitable for Japanese consumers and remunerative to ASEAN timber producers. This meeting should be utilized to promote processed products in Japan as well.

The policy proposals discussed earlier (export charges and market development fund) apply also to log exports in Japan. The basic purpose of the fund now would be to penetrate the Japanese market through the establishment of a trading channel either by setting up a sales branch office or trade contact (i.e., agent or importer). This sales branch or trade contact in turn could feedback whatever new developments are emerging in the Japanese market. Through the fund the marketing ability of ASEAN producers could be improved, and the increase in sales revenue will represent a positive return to the fund.

To reduce some of the risk involved in log production and forestry investment in general, resulting from instability of hardwood log markets and prices, the ASEAN could establish a timber marketing board to handle the marketing of this and other wood products overseas, especially in Japan.

United States

The results of this and earlier studies by Chou and Buongiorno (1982, 1983) indicate that import demand for hardwood plywood in the United States, the major plywood market, is more likely elastic. The use of hardwood plywood imports in the residential construction industry has been found to decline over time due to biased technical change and probably to substitution effects. It appears that measures to improve the competitiveness of hardwood plywood in the construction industry would more likely benefit the ASEAN processors. One measure would be to set export charges on plywood at a low level, perhaps to collect part of the stumpage value of the timber used in production, or to permit its exports free of charge. This will enable the ASEAN processors to lower the price of hardwood plywood sold in the United States market. Furthermore, such a policy encourages domestic processing. Alternatively, improvements in plywood production technology which reduce production costs might yield higher returns to domestic processors and enhance the output of the processing industry. Again, this would make it possible to sell the plywood at a competitive price.

To facilitate marketing of plywood in the United States, the ASEAN Panel Products Federation should consider the possibility of taking this function to improve the dependability of supply to the U.S. residential construction industry.

As a whole, market and product research and development programs are needed. These programs would facilitate development of new markets both for existing and new products, and they would help reduce the pressure on domestic processors to find markets.

C. Need for Future Research

This research was undertaken as a first step in understanding import demand for unprocessed and processed products in the major consuming countries and has considered primarily a limited number of economic factors that were found to have ~~signi~~ficant influence on demand. Yet this author sees several other factors that must be attended to in future research of this type. Hence, some recommendations are listed below:

1. It is recommended that a similar study be made to cover importing countries other than the United States, South Korea and Japan, and other processed products such as particleboard.
2. Future research may have to incorporate such policy variables as tariffs, foreign exchange rates and nontariff measures as explanatory variables. Tariff and nontariff barriers are two major policies that cause serious impediments on exports of processed products, and therefore their relative effects on import demand are important for the policy-makers and producers in the region.
3. For better knowledge of short term fluctuations in import demand, future research may consider using monthly series. The use of monthly data will also reveal more accurately the effects of adjustment and

expectation lags. As well, the results will provide a better basis for short term forecasting of import demand.

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Appendix A

A1. Data used for the United States

Year		PMP	PLU	PL	PK
1967	1	1.000	1.000	1.000	1.000
	2	0.909	1.015	1.021	0.980
	3	0.880	1.053	1.056	0.986
	4	0.911	1.096	1.053	0.988
1968	1	0.866	1.124	1.015	1.002
	2	0.862	1.176	1.046	1.042
	3	0.880	1.253	1.071	1.099
	4	0.886	1.290	1.055	1.099
1969	1	0.914	1.468	1.057	1.126
	2	0.960	1.403	1.092	1.169
	3	0.946	1.130	1.117	1.217
	4	0.805	1.110	1.113	1.244
1970	1	0.733	1.036	1.094	1.278
	2	0.682	1.026	1.117	1.286
	3	0.674	1.013	1.118	1.293
	4	0.686	0.993	1.139	1.283
1971	1	0.707	1.116	1.126	1.185
	2	0.648	1.240	1.160	1.144
	3	0.760	1.342	1.181	1.179
	4	0.776	1.278	1.206	1.188
1972	1	0.671	1.331	1.179	1.161
	2	0.658	1.385	1.201	1.149
	3	0.685	1.431	1.222	1.155
	4	0.687	1.430	1.219	1.168
1973	1	0.639	1.532	1.194	1.194
	2	0.816	1.674	1.228	1.202
	3	0.945	1.610	1.250	1.241
	4	0.858	1.586	1.241	1.304
1974	1	0.969	1.503	1.183	1.334
	2	0.912	1.547	1.166	1.359
	3	0.923	1.856	1.146	1.410
	4	0.848	1.131	1.154	1.439
1975	1	0.668	1.170	1.090	1.424
	2	0.637	1.315	1.121	1.388
	3	0.645	1.278	1.138	1.383
	4	0.646	1.233	1.133	1.357
1976	1	0.721	1.377	1.116	1.348
	2	0.705	1.354	1.137	1.351
	3	0.784	1.436	1.142	1.366
	4	0.910	1.485	1.149	1.374
1977	1	1.002	1.538	1.100	1.368
	2	0.973	1.473	1.112	1.359
	3	1.003	1.619	1.119	1.368
	4	1.067	1.556	1.118	1.374

1978	1	0.872	1.597	1.054	1.393
	2	0.873	1.612	1.126	1.420
	3	0.850	1.725	1.149	1.464
	4	0.899	1.722	1.132	1.500
1979	1	0.928	1.670	1.074	1.547
	2	1.057	1.692	1.076	1.587
	3	1.161	1.755	1.096	1.654
	4	1.258	1.607	1.069	1.720
1980	1	1.273	1.445	1.003	1.329
	2	1.240	1.316	1.011	1.974
	3	1.114	1.346	1.033	1.857
	4	0.905	1.296	1.023	1.950
1981	1	0.865	1.197	0.989	2.034
	2	0.880	1.162	0.993	2.138
	3	0.925	1.084	0.990	2.248
	4	0.927	0.945	1.003	2.379
1982	1	0.875	0.903	0.968	2.280
	2	0.796	0.920	0.990	2.328
	3	0.716	0.935	1.030	2.298
	4	0.676	0.909	1.007	2.080
1983	1	0.639	1.210	0.986	1.997
	2	0.627	1.332	0.994	1.870
	3	0.657	1.281	1.000	1.870
	4	0.683	1.170	0.981	1.840

Year		PDP	POM	Q
1967	1	1.000	1.000	1.000
	2	0.996	1.002	1.752
	3	1.087	0.996	1.752
	4	1.073	1.025	1.559
1968	1	1.123	1.005	1.371
	2	1.178	1.003	2.077
	3	1.301	0.998	1.940
	4	1.597	0.994	1.706
1969	1	2.086	1.005	1.541
	2	1.220	0.993	2.146
	3	1.022	0.987	1.775
	4	1.082	0.978	1.417
1970	1	1.028	1.057	1.211
	2	1.079	1.057	1.834
	3	1.106	1.052	1.876
	4	1.030	1.016	1.770
1971	1	1.125	1.060	1.784
	2	1.101	1.083	2.770
	3	1.192	1.108	2.655
	4	1.185	1.111	2.353
1972	1	1.284	1.091	2.614
	2	1.358	1.112	3.059
	3	1.381	1.117	2.949
	4	1.339	1.103	2.559
1973	1	1.602	1.056	2.238
	2	1.760	1.028	2.949
	3	1.177	0.987	2.532
	4	1.411	0.986	1.720
1974	1	1.323	1.007	1.481
	2	1.420	1.009	2.110
	3	1.251	1.029	1.564
	4	1.209	1.004	1.045
1975	1	1.133	1.106	0.889
	2	1.267	1.117	1.495
	3	1.170	1.109	1.614
	4	1.160	1.102	1.371
1976	1	1.380	1.136	1.298
	2	1.339	1.162	2.022
	3	1.384	1.163	2.004
	4	1.479	1.152	1.770
1977	1	1.535	1.192	1.688
	2	1.464	1.174	2.669
	3	1.666	1.182	2.577
	4	1.615	1.168	2.197

1978	1	1.652	1.199	1.660
	2	1.558	1.205	2.866
	3	1.604	1.204	2.577
	4	1.620	1.182	2.165
1979	1	1.578	1.235	1.495
	2	1.406	1.217	2.486
	3	1.397	1.190	2.293
	4	1.277	1.020	1.743
1980	1	1.171	1.172	1.100
	2	1.074	1.180	1.399
	3	1.261	1.143	1.788
	4	1.226	1.109	1.665
1981	1	1.153	1.119	1.224
	2	1.124	1.122	1.568
	3	1.055	1.105	1.279
	4	0.981	1.112	0.977
1982	1	0.968	1.135	0.816
	2	0.975	1.138	1.266
	3	0.973	1.122	1.435
	4	0.969	1.101	1.394
1983	1	1.063	1.093	1.490
	2	1.074	1.122	2.229
	3	1.073	1.128	2.279
	4	1.037	1.113	1.853

Notes: PMP = Weighted average Divisia price index of hardwood log imports
PLU = Divisia price index of Douglas-fir lumber
PL = Average weekly earnings Divisia index of special trade construction workers used as a measure of the price of labor in residential construction
PK = Average quarterly home mortgage rates Divisia index, used as a measure of the price of capital
PDP = Divisia price index of softwood plywood
POM = Aggregate Divisia price index of fabricated structural steel and portland cement used as an indicator of the price of non-wood construction materials
Q = Y = Index number of new housing units started in each quarter

Year		QMP	QLU	QL
1967	1	1.000	1.000	1.000
	2	1.157	1.130	1.094
	3	1.572	1.083	1.187
	4	1.952	1.050	1.137
1968	1	1.550	1.114	1.029
	2	2.030	1.264	1.132
	3	1.783	1.217	1.210
	4	2.097	1.131	1.182
1969	1	2.025	1.067	1.086
	2	2.574	1.234	1.184
	3	1.811	1.100	1.258
	4	1.387	0.963	1.224
1970	1	1.048	1.077	1.107
	2	1.345	1.158	1.160
	3	2.470	1.100	1.208
	4	2.284	0.963	1.174
1971	1	1.759	1.058	1.063
	2	2.208	1.198	1.174
	3	1.962	1.122	1.258
	4	1.526	1.182	1.244
1972	1	2.060	1.237	1.124
	2	2.244	1.324	1.231
	3	2.403	1.200	1.285
	4	2.423	1.154	1.248
1973	1	2.563	1.204	1.148
	2	2.703	1.311	1.256
	3	1.836	1.210	1.354
	4	1.670	1.131	1.330
1974	1	1.550	1.086	1.194
	2	1.354	1.273	1.261
	3	0.025	0.997	1.290
	4	0.195	0.907	1.219
1975	1	0.332	0.908	1.021
	2	0.851	1.058	1.043
	3	0.806	1.045	1.106
	4	1.055	1.032	1.076
1976	1	0.941	1.111	0.962
	2	0.972	1.101	1.036
	3	1.070	1.116	1.098
	4	1.295	1.140	1.084
1977	1	0.896	1.135	0.979
	2	0.718	1.225	1.114
	3	0.812	1.113	1.203
	4	0.556	1.182	1.190

1978	1	0.845	1.206	1.071
	2	0.950	1.326	1.453
	3	1.393	1.176	1.372
	4	1.098	1.167	1.345
1979	1	1.135	1.123	1.194
	2	1.383	1.204	1.332
	3	1.006	1.111	1.425
	4	0.831	1.076	1.399
1980	1	0.660	1.038	1.243
	2	0.454	0.950	1.303
	3	0.682	0.971	1.366
	4	1.043	0.937	1.348
1981	1	1.680	0.921	1.179
	2	1.249	0.977	1.288
	3	1.575	0.810	1.343
	4	1.501	0.816	1.280
1982	1	0.816	0.684	1.077
	2	0.762	0.820	1.201
	3	2.389	0.847	1.271
	4	2.752	0.849	1.221
1983	1	1.947	0.959	1.059
	2	3.610	1.131	1.184
	3	5.609	1.010	1.317
	4	5.971	0.995	1.316

Year		QK	QDP	C
1967	1	1.000	1.000	5.000
	2	1.697	1.032	6.013
	3	1.756	0.722	6.297
	4	1.747	1.081	6.967
1968	1	1.487	1.140	6.288
	2	2.080	1.203	7.840
	3	1.771	1.214	7.694
	4	1.872	1.260	8.368
1969	1	1.704	1.231	8.613
	2	2.163	1.205	9.110
	3	1.762	1.095	7.610
	4	1.407	1.138	6.532
1970	1	1.075	1.110	5.672
	2	1.621	1.209	6.895
	3	1.701	1.247	7.824
	4	1.741	1.234	7.505
1971	1	1.737	1.323	7.178
	2	2.863	1.377	8.974
	3	2.893	1.387	9.366
	4	2.620	1.402	8.884
1972	1	2.531	1.518	9.053
	2	3.573	1.552	10.758
	3	3.381	1.507	10.669
	4	3.169	1.496	10.297
1973	1	3.094	1.597	10.699
	2	4.024	1.607	13.023
	3	3.291	1.481	10.767
	4	2.077	1.460	9.255
1974	1	2.172	1.403	8.953
	2	3.498	1.495	11.066
	3	1.323	1.381	6.237
	4	1.845	1.148	6.662
1975	1	2.148	1.209	6.753
	2	4.142	1.361	10.371
	3	4.483	1.441	10.854
	4	4.165	1.448	10.401
1976	1	3.981	1.531	10.471
	2	5.995	1.568	13.314
	3	5.958	1.579	13.691
	4	6.005	1.590	14.336
1977	1	7.208	1.624	15.576
	2	8.553	1.646	17.333
	3	8.609	1.612	17.869
	4	7.889	1.584	16.643

1978	1	7.186	1.649	15.871
	2	9.670	1.681	20.309
	3	8.283	1.575	18.764
	4	8.142	1.631	18.686
1979	1	6.501	1.645	16.195
	2	9.117	1.687	21.031
	3	8.203	1.601	19.751
	4	6.632	1.541	17.066
1980	1	4.482	1.483	10.821
	2	3.833	1.105	11.594
	3	6.801	1.431	17.608
	4	6.999	1.467	18.729
1981	1	4.647	1.535	14.752
	2	5.621	1.531	17.087
	3	3.813	1.363	13.598
	4	3.068	1.177	11.947
1982	1	3.037	1.231	10.535
	2	3.965	1.338	13.142
	3	4.430	1.493	15.525
	4	5.974	1.518	17.842
1983	1	6.887	1.644	18.734
	2	10.518	1.745	26.107
	3	10.661	1.768	27.845
	4	10.470	1.732	27.406

Notes: QMP = Divisia quantity index of hardwood plywood imports

QLU = Divisia quantity index of Douglas-fir lumber shipments used as a proxy for the quantity of domestic lumber utilized by the residential construction industry

QL = Divisia index of weighted average number of special trade construction workers used as indicator of the labor input

QK = Divisia index of average quarterly new mortgage loans extended by all Savings and Loan Associations in the U.S. for home construction purposes, used as an indicator of capital input

QDP = Divisia quantity index of softwood plywood produced in each quarter, used as an indicator of domestic plywood utilized by the industry

C = Total cost calculated as the sum of expenditures spent by the industry on each input

A2. Data used for South Korea

Year		PML	POM	ML	INP
1970	1	1.000	1.000	1.000	1.000
	2	1.279	0.996	1.339	1.180
	3	0.879	0.999	1.733	1.186
	4	0.501	1.030	4.037	1.262
1971	1	1.874	1.038	0.882	1.266
	2	1.303	1.061	1.790	1.460
	3	1.144	1.090	1.987	1.418
	4	1.626	1.115	0.867	1.373
1972	1	8.339	1.198	0.171	1.352
	2	0.698	1.240	2.181	1.661
	3	4.479	1.255	0.463	1.610
	4	8.515	1.253	0.243	1.790
1973	1	9.443	1.270	0.214	1.527
	2	15.440	1.293	0.308	1.807
	3	14.761	1.334	0.276	1.947
	4	16.038	1.396	0.242	2.197
1974	1	19.983	1.689	0.242	2.267
	2	18.226	1.888	0.276	2.587
	3	19.380	1.937	0.229	2.437
	4	12.308	2.011	0.207	2.447
1975	1	12.619	2.234	0.199	2.457
	2	12.874	2.365	0.319	2.777
	3	12.072	2.437	0.246	2.857
	4	12.077	2.488	0.333	3.253
1976	1	12.845	2.560	0.271	3.397
	2	14.513	2.625	0.337	3.923
	3	14.660	2.660	0.337	3.993
	4	18.920	2.720	0.344	3.973
1977	1	18.132	2.822	0.330	3.867
	2	17.060	2.882	0.367	4.390
	3	12.773	2.939	0.347	4.537
	4	16.559	2.992	0.441	4.733
1978	1	16.754	3.131	0.440	4.920
	2	16.265	3.207	0.418	5.663
	3	16.787	3.281	0.412	5.650
	4	17.628	3.378	0.466	6.083

Notes: PML = Weighted average price index of hardwood log imports

POM = Producer price index for a representative list of commodities used as a proxy for price of other intermediate products

ML = Quarterly average volume index of hardwood log imports

INP = Index of industrial (manufacturing) production

A3. Data used for Japan

Year		PML	PDL	ML	Q
1979	1	1.000	1.000	1.000	1.000
	2	1.288	1.160	1.039	1.312
	3	1.804	1.552	1.127	1.309
	4	2.101	1.664	1.046	1.103
1980	1	1.815	1.794	0.838	0.970
	2	1.907	1.859	0.956	1.145
	3	1.591	1.730	0.862	1.001
	4	1.347	1.625	0.800	0.890
1981	1	1.287	1.572	0.618	0.797
	2	1.386	1.558	0.684	1.098
	3	1.291	1.566	0.702	0.891
	4	1.291	1.602	0.702	0.850
1982	1	1.566	1.669	0.642	0.769
	2	1.539	1.681	0.666	0.966
	3	1.545	1.726	0.666	0.950
	4	1.548	1.696	0.847	0.935
1983	1	1.214	1.637	0.648	0.927
	2	1.166	1.580	0.648	1.110
	3	1.294	1.571	0.692	1.079
	4	1.294	1.592	0.692	1.089

Notes: PML = Weighted average price index of hardwood log imports
PDL = Average domestic wholesale price index of lauan logs in Tokyo used as a proxy for average domestic price of logs in Japan
ML = Quarterly average volume index of hardwood log imports
Q = Index number of new dwellings constructed.

Appendix B

A Note on Technical Change in the U.S. Residential Construction Industry, 1967 - 1983

The results of likelihood ratio tests (see Table 5.3) indicated the existence of biased technical change in input use in the residential construction industry over time. The estimated biases of technical change with respect to the price of each input (γ_{it}, i = K, L, MP, DP, LU) are as follows:

Technical Change Parameters and t-ratios: Translog Model

K	L	MP	DP	LU
.009	-.002	-.003	-.001	-.003
(18.414)	(-13.742)	(8.466)	(-5.086)	

Note: t-ratios are in parentheses.

Each of the parameter estimate measures the change in the share of a particular input in total production cost with respect to time. A positive value of the parameter estimate would imply that technical change uses the corresponding input, or that the rate of technical change decreases with a rise in price of that input. Conversely, technical change saves a given input if its estimated value is negative. In other words the rate of technical change will increase with the price of the given input. In the U.S. residential construction industry, technical change has been capital using, and saving labor, hardwood plywood imports, domestic plywood and domestic lumber over the period from 1967 to 1983. Alternatively the rate of technical change appeared to decline with the price of capital and increase with the prices of hardwood plywood imports, labor, domestic plywood and domestic lumber. It is very apparent from the parameter estimates above that the technical change has been saving more imported hardwood plywood and domestic lumber than domestic plywood or labor throughout the period. However, the negative estimated values of hardwood plywood imports, domestic plywood and domestic lumber suggest that the technical change may have been using other intermediate inputs (i.e., other non-wood construction materials) that were not considered in the model.

Based on the estimated value of the parameter (γ_{tt}) which is equal to -.000, the rate of technical change has increased, but this increase was almost negligible. Perhaps the increased rate of technical change that occurred from saving hardwood plywood imports, domestic plywood, domestic lumber and labor has been offset by the decreasing effect on the rate of using capital in residential construction. Thus the increase in the rate of technical change over time was nil.

Appendix C

Selection of the Appropriate Polynomial Distributed-lag Import Demand Model

C1. The United States

As may be recalled in chapter four, the optimal value found for the length of the lag k=4. Given this information, the next step is to search for the value of the degree of the approximating polynomial. Two values of the degree were experimented: second-and third-degree polynomials. The second degree polynomial for the Almon lag is associated with the postulate that lagged influences on import demand in the current period can best be described by a single turning point. On the other hand, a third-degree polynomial is based on the notion that more than one turning point might best characterize the effects of the lagged values of the explanatory variables. In determining the optimal value of the degree, the model was estimated without any end-point constraints. The particular degree that yields a higher coefficient of determination adjusted for degrees of freedom, small standard error and insignificant autocorrelation is considered optimal and selected.

The results of estimation are presented in Tables C1.1 and C1.2. It is apparent from the table that a second-degree polynomial is preferable than third-degree polynomial on the basis of the established criteria. It should be noted that the estimated Durbin-Watson statistics are in the uncertain range (at the one percent level). No attempt has been made to improve these statistics by resorting to efficient

Table C1.1. Results of the Unconstrained Second Degree Polynomial Distributed-Lag Demand Model

Lag Number k (Quarters)	Second Degree Polynomial without End Point Restriction				
	Elasticity Coefficients of Independent Variables				
	PMP_{t-k}	PK_{t-k}	POM_{t-k}	PLU_{t-k}	Q_{t-k}
Total effect	-.731	1.031	-2.409	-1.882	1.525
Current quarter	-.081 (.497)	1.204 (.894)	-1.348 (1.286)	.338 (.504)	.702 (.282)**
One quarter lag	-.528 (.195)*	1.079 (.443)**	-1.571 (.720)**	.160 (.280)	.346 (.175)***
Two quarters lag	-.561 (.332)***	.580 (.649)	-1.137 (1.028)	-.197 (.371)	.148 (.157)
Three quarters lag	-.179 (.206)	-.206 (.455)	-.048 (.829)	-.733 (.274)**	.107 (.154)
Four quarters lag	.617 (.834)	-1.539 (.839)***	1.696 (1.522)	-1.448 (.554)**	.223 (.260)
Mean lag (No. of Quarters)	0.50	4.50	1.10	4.00	1.20
Constant	-4.143 (2.272)				
Adjusted R^2 (DF)	.69 (48)				
Standard error	.331				
d statistic	1.416				

Table C1.2. Results of the Unconstrained Third Degree Polynomial Distributed-Lag Demand Model

Lag Number k (Quarters)	Third-Degree Polynomial without End Point Restriction				
	Elasticity Coefficients of Independent Variables				
	PMP_{t-k}	PK_{t-k}	POM_{t-k}	PLU_{t-k}	Q_{t-k}
Total effect	-.745	1.002	2.329	-1.868	1.475
Current quarter	.148 (.617)	.814 (1.064)	-1.302 (1.696)	.654 (.560)	.690 (.450)
One quarter lag	-.832 (.583)	1.976 (.950)**	-1.498 (1.818)	-.463 (.534)	.418 (.218)***
Two quarters lag	-.670 (.352)***	.623 (.735)	-1.579 (1.159)	-.126 (.382)	.133 (.171)
Three quarters lag	.013 (.602)	-1.153 (.967)	-.547 (1.731)	-.037 (.555)	.010 (.243)
Four quarters lag	.596 (.544)	-1.259 (.904)	2.597 (2.166)	-1.897 (.661)*	.223 (.395)
Mean lag (No. of Quarters)	.50	5.25	1.75	4.50	1.00
Constant	-3.852 (2.497)				
Adjusted R^2 (DF)	.68 (43)				
Standard error	.335				
d statistic	1.381				

Table C1.3. Results of the Constrained Second Degree Polynomial Distributed-Lag Demand Model

Lag Number k (Quarters)	Constrained to Zero at the Far End Point				
	Elasticity Coefficients of Independent Variables				
	PMP_{t-k}	PK_{t-k}	POM_{t-k}	PLU_{t-k}	Q_{t-k}
Total effect	-.731	1.031	-2.409	-1.882	1.525
Current quarter	-.081 (.497)	1.204 (.894)	-1.348 (1.286)	.338 (.504)	.702 (.282)**
One quarter lag	-.528 (.195)*	1.079 (.443)**	-1.571 (.720)**	.160 (.280)	.346 (.175)***
Two quarters lag	-.561 (.332)***	.580 (.649)	-1.137 (1.028)	-.197 (.371)	.148 (.157)
Three quarters lag	-.179 (.206)	-.293 (.455)	-.048 (.829)	-.733 (.274)**	.107 (.154)
Four quarters lag	.617 (.834)	-1.539 (.839)***	1.696 (1.522)	-1.448 (.554)**	.223 (.260)
Mean lag (No. of Quarters)	.50	4.50	1.10	4.00	1.20
Constant	-4.143 (2.272)				
Adjusted R^2 (DF)	.69 (48)				
Standard error	.331				
d statistic	1.416				

Table C1.4. Results of the Constrained Second Degree Polynomial Distributed-Lag Demand Model

Lag Number k (Quarters)	Constrained to Zero at the Extreme Points				
	Elasticity Coefficients of Independent Variables				
	PMP_{t-k}	PK_{t-k}	POM_{t-k}	PLU_{t-k}	Q_{t-k}
Total effect	-.650	1.048	-2.104	-2.564	2.091
Current quarter	-.093 (.054)***	.150 (.053)*	-.300 (.175)***	-.366 (.067)*	.299 (.048)*
One quarter lag	-.148 (.086)***	.240 (.085)*	-.481 (.280)***	-.586 (.108)*	.478 (.077)*
Two quarters lag	-.167 (.097)***	.269 (.095)*	-.541 (.315)***	-.659 (.121)*	.534 (.087)*
Three quarters lag	-.148 (.086)***	.240 (.085)*	-.481 (.280)***	-.586 (.108)*	.478 (.077)*
Four quarters lag	-.093 (.054)***	.150 (.053)*	-.300 (.175)***	-.366 (.067)*	.299 (.048)*
Mean lag (No. of Quarters)	2.00	2.00	2.00	2.00	2.00
Constant	-7.262 (1.978)				
Adjusted R^2 (DF)	.58 (58)				
Standard error	.386				
d statistic	1.120				

Table C1.5. F-tests for End-Point Restrictions

Restrcition	RSS	DF	Critical F Values $F_{0.99}$	Critical F Values $F_{0.95}$	Calculated F
Zero	5.274	-	-	-	-
Far-end	5.274	1.57	7.12	4.02	0.00
Both ends	8.627	2.28	5.45	3.34	18.124

estimation technique, such as instrumental variables estimation, in order not to complicate the interpretation of the results and also to permit an easy comparison of elasticity estimates of model 4 with those of the other models. Moreover, in practice, there are some real difficulties in finding the variables to play the role of instruments considering the criteria to be satisfied such as: the instruments should be exogenous, correlated to dependent variable but must not be collinear with the exogenous variables.

The second-degree polynomial unconstrained at the extreme points was, in turn, tested against two alternative specifications of the model. In other words, the former specification is the maintained null hypothesis and the latter two are alternative hypotheses. The alternatives include the imposition of one far end-point and both end-points constraints on the polynomial distribution. An F-test was used to determine the suitable specification of model 4. Tables C1.3 through C1.5 report the estimated elasticity coefficients of the alternative specifications and F-test statistics. The results of the F-tests (Table C1.5) imply that a second-degree polynomial constrained at both end-points is an acceptable representation of model 4. This specification is significantly different from zero at the one and five percent levels; however, it is not free of any problem. In particular, the overall explanatory power of the model has declined considerably from .69 to .58 and the residuals have displayed a significant positive autocorrelation. The inability to solve the latter problem has resulted in adoption of the unconstrained second-degree polynomial. It should be noted further that the unconstrained and the one far end-point constrained specifications have similar parameter estimates. Further discussion of estimated demand elasticities of the unconstrained second-degree polynomial is made in Chapter five.

C2. South Korea

Table C2.1 shows the estimated coefficients of model 3 using a polynomial lag structure of order k=4 and degree r=2 and 3 without end-point restriction. In both quadratic and cubic polynomials in m, the long run demand elasticities associated with import price and industrial production index satisfy the a priori expectations (i.e., the expected signs of the elasticity coefficients). On the bases of coefficient of determination adjusted for degrees of freedom and standard error of the estimate, the third degree polynomial was superior to the second degree polynomial. On the other hand, the latter was free of serial correlation in the residuals, while the Durbin-Watson statistic of the former was in the uncertain range at the one percent significance level. In both cases, the mean lag in import demand due to a change in (current and previous) import price was approximately one quarter, which is consistent with the result of submodel 2 in model 2. However, the second degree polynomial yielded a mean lag of 2.25 quarters in hardwood log imports due to production activity which is exactly half of that estimated in the third degree polynomial. Obviously, these two mean lag values differ from the one obtained in model 2.

Given the higher $\bar{R}^2$ and lower standard error in the third degree polynomial compared to quadratic polynomial, and the expectation that the d statistic associated with the former will not affect the time adjustment pattern in import

Table C2.1. Results of the Unconstrained Second and Third Degree Polynomial Distributed-Lag Demand Model

Lag Number k (Quarters)	Second Degree Polynomial		Third Degree Polynomial	
	Elasticity Coefficients of Independent Variables		Elasticity Coefficients of Independent Variables	
	PML_{t-k}	INP_{t-k}	PML_{t-k}	INP_{t-k}
Total effect	-.846	.804	-.862	.831
Current quarter	-.698 (.114)*	1.370 (.613)**	-.786 (.089)*	2.148 (.659)*
One quarter lag	-.141 (.049)*	.240 (.319)	.065 (.065)	-.464 (.636)
Two quarters lag	.124 (.072)***	-.365 (.452)	.135 (.055)**	-.289 (.345)
Three quarters lag	.095 (.057)	-.444 (.307)	-.102 (.069)	.341 (.640)
Four quarters lag	-.226 (.098)**	.003 (.635)	-.175 (.076)**	-.905 (.683)
Mean lag (No. of Quarters)	1.00	2.25	1.00	4.50
Constant	8.456		8.338 (.176)	
Adjusted R^2 (DF)	.81 (25)		.89 (23)	
Standard error	.283		.215	
d statistic	1.856		1.291	

Table C2.2. Results of the Constrained Third Degree Polynomial Distributed-Lag Demand Model

Lag Number k (Quarters)	Constrained to Zero at the Extreme Points		Constrained to Zero at the Far-End Points	
	Elasticity Coefficients of Independent Variables		Elasticity Coefficients of Independent Variables	
	PML_{t-k}	INP_{t-k}	PML_{t-k}	INP_{t-k}
Total effect	-.748	.790	-.859	.841
Current quarter	-.231 (.105)**	.394 (.569)	-.768 (.090)*	1.552 (.534)*
One quarter lag	-.270 (.088)*	.406 (.460)	.036 (.060)	.215 (.393)
Two quarters lag	-.192 (.034)*	.203 (.077)**	.153 (.051)*	-.345 (.339)
Three quarters lag	-.072 (.088)	-.045 (.458)	-.054 (.044)	-.392 (.232)
Four quarters lag	.017 (.105)	-.169 (.568)	-.226 (.061)*	-.189 (.368)
Mean lag (No. of Quarters)	1.10	2.00	1.00	2.90
Constant	8.164 (.352)		8.424 (.179)	
Adjusted R^2 (DF)	.53 (27)		.88 (25)	
standard error	.444		.221	
d statistic	2.332		1.375	

Table C2.3. F-tests for End-Point Restrictions

Restriction	RSS	DF	Critical F Value		Calculated F
			$F_{0.99}$	$F_{0.95}$	
Zero	1.066	-	-	-	-
Far-end	1.225	1.24	7.82	4.26	3.58
Both ends	5.317	2.12	6.93	3.88	47.48

demand, a cubic polynomial was chosen.

The polynomial distributed-lag model of order k=4 and degree r=3 with no end-point restriction became the maintained null hypothesis and was tested against two alternative specifications of the model. These alternatives refer to polynomial distributed-lag models constrained at the one far end-point and both end-points, respectively. Results of estimation of the alternative models and the F-tests are reported in Tables C2.2 and C2.3 consecutively. As the F-tests reveal, a restriction on the polynomial lag structure at the extreme points cannot be rejected in the case of import demand for hardwood logs, even at the one percent significance level. Model 3 therefore specifies a polynomial lag structure of order k=4 and degree r=3 constrained at the extreme points. Discussion of the estimated elasticity coefficients of this particular model is made in chapter five.

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In Table C3.1 the estimated coefficients of model 3 using the Almon model with an optimal lag length of four and degree r=2 and 3 unconstrained at any end point are presented. The third degree polynomial seemed to be superior than the second degree polynomial in terms of adjusted coefficient of determination and standard error. On the contrary, the latter did not appear to have a significant serial correlation in the residuals at the one percent level, while the former has a significant negative autocorrelation. Due to strong serial correlation in the third degree polynomial, the standard error was likely underestimated, and hence use of this particular degree would lead to invalid inference procedure. As a result, the second degree polynomial was considered more appropriate to represent the pattern of lagged influences of import price and construction activity on current demand for hardwood log imports.

Tables C3.2 and C3.3 show the estimated parameter coefficients of the quadratic polynomial constrained at the extreme points and at the one far end-point, and the results of F tests respectively. As these tables indicate, the polynomial distribution should be unconstrained since the alternative specifications could not be accepted both at the one and five percent significance levels. The estimated demand elasticities of the unconstrained second degree polynomial are discussed at some length in Chapter five.

Table C3.1. Results of the Unconstrained Second and Third Degree Polynomial Distributed-Lag Demand Model

Lag Number k (Quarters)	Second Degree Polynomial		Third Degree Polynomial	
	Elasticity Coefficients of Independent Variables		Elasticity Coefficients of Independent Variables	
	PML_{t-k}	Q_{t-k}	PML_{t-k}	Q_{t-k}
Total effect	1.073	.443	.805	.518
Current quarter	.502 (.279)	.348 (.162)***	.506 (.273)	.102 (.196)
One quarter lag	.238 (.067)*	.217 (.106)***	.039 (.153)	.428 (.139)**
Two quarters lag	.094 (.111)	.087 (.103)	.092 (.099)	.105 (.092)
Three quarters lag	.071 (.071)	-.041 (.099)	.214 (.141)	-.220 (.125)
Four quarters lag	.169 (.199)	-.168 (.199)	-.047 (.208)	.103 (.234)
Mean lag (No. of Quarters)	1.000	1.000	.850	.750
Constant	-.708		-.606	
Adjusted R^2 (DF)	.65 (9)		.72 (7)	
Standard error	.077		.068	
d statistic	2.485		2.921	

Table C3.2. Results of the Constrained Second Degree Polynomial Distributed-Lag Demand Model

Lag Number (Quarters)	Constrained to Zero at the Extreme Points		Constrained to Zero at the Far-End Points	
	Elasticity Coefficients of Independent Variables		Elasticity Coefficients of Independent Variables	
	PML_{t-k}	Q_{t-k}	PML_{t-k}	Q_{t-k}
Total effect	.514	.573	.801	.477
Current quarter	.073 (.036)	.082 (.045)	.321 (.095)	.329 (.149)
One quarter lag	.117 (.057)	.131 (.072)	.244 (.059)	.161 (.068)
Two quarters lag	.132 (.064)	.147 (.081)	.144 (.057)	.044 (.077)
Three quarters lag	.117 (.057)	.131 (.072)	.079 (.057)	-.022 (.089)
Four quarters lag	.073 (.036)	.082 (.045)	.032 (.040)	-.036 (.036)
Mean lag (No. of Quarters)	2.000	2.000	1.000	.750
Constant	-.512		-.610	
Adjusted R^2 (DF)	.53 (13)		.69 (11)	
Standard error	.088		.072	
d statistic	2.037		2.406	

Table C3.3. F-tests for End-Point Restrictions

Restriction	RSS	DF	Calculated F Values		Calculated F
			$F_{0.99}$	$F_{0.95}$	
Zero	.0531	-	-	-	-
Far-end	.0565	1.9	10.56	5.12	4.142
Both ends	.1019	2.5	13.27	5.74	0.583